THE JUNE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

JUNE, 1927

SKELETAL RECORDS OF MORTALITY

By Professor T. WINGATE TODD

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Introduction

There is a profound difference between the potential duration of life and the action duration of life. The former holds for all humanity in all periods of man's history, but the latter is modified by very many factors arising from the environment. In a recent paper Pearl has differentiated clearly between these two views of the duration of life.[1] He gives good evidence for the presumption that potential duration of life is definite and unchangeable: it is a function of bodily organization. It is seen in all forms of life: after a certain definite period death is a natural consequence whether the living thing be plant or animal, invertebrate or vertebrate, cold blooded or warm blooded, bird or mammal. Rarely, however, is this full potential span of life realized: some environmental factor steps in to terminate life before its natural course is run.

So far as humanity is concerned, Karl Pearson, many years ago, analyzed the mortality curve for England[2] and demonstrated that it is a very complex curve of several components, best conceived as curves of death specially related to the successive periods of life. Thus Pearson separated off curves of infantile death, of death in childhood, in adolescence, in middle age and in senility (Fig. 1). In a fascinating metaphor the author represents Death as attacking his victims in divers manner as they cross the bridge of life. Five deaths, variously armed, take toll of humanity: the bones of its ancestry for the baby, a machine gun for the children, an arrow for the adolescent, a blunderbuss for the middle-aged and a rifle for the full of years. Death carries off in old age nearly one half the human beings of modern days. This is the death "apart from the selection of infancy, the danger of infectious disease in childhood, and of excess or accident in youth or later life." The fire of the middle age Death is "slow and scattered and his curve of destruction a very flat-topped one." This plateau of the middle age mortality curve is significant: we shall find it quite evident in all the studies to be presented in this paper.

More philosophically but none the less realistically Conrad has portrayed old age death characteristic of modern days in creatures who "are forgotten by time, and live untouched by years till death gathers them up into its compassionate bosom: the faithful death that never forgets in the press of work the most insignificant of its children."[3]

The actual duration of life as exemplified by different peoples in successive periods of the existence of humanity must always exercise a fascination over

[1] Pearl, R., 1926, "Span of Life and Average Duration of Life," *Natural History*, Vol. 26, pp. 26–30.

[2] Pearson, K., 1897, "Chances of Death," London and New York, pp. 1–41.

[3] Conrad, J., 1898, "The Idiots. Tales of Unrest." London, p. 57.

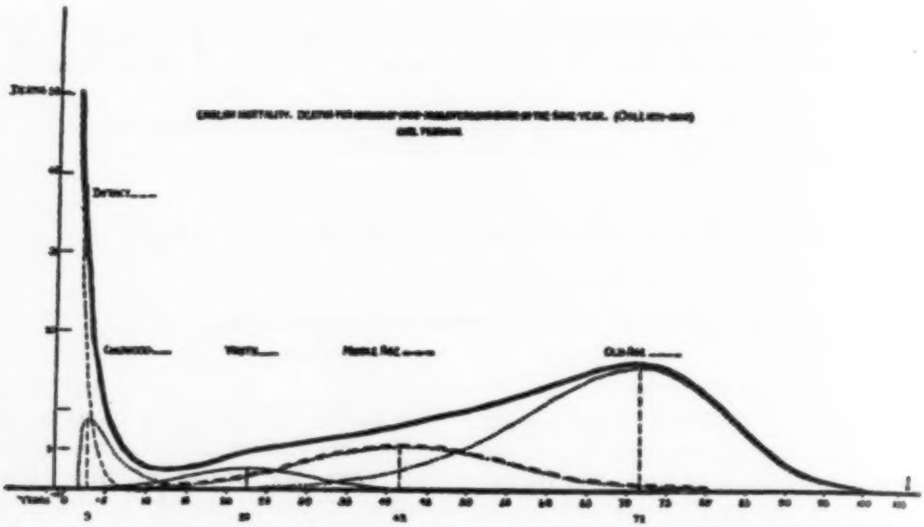

FIG. 1. ANALYSIS OF THE CURVE OF DEATH OF 1,000 MODERN ENGLISH MALES. BY KARL PEARSON. NOTE THE PEAKS OF MORTALITY IN INFANCY, CHILDHOOD, ADOLESCENCE, MIDDLE AGE AND SENILITY. THE FLAT-TOPPED CURVE OR PLATEAU OF MIDDLE AGE DEATH IS TO BE SEEN IN ALL SUCCEEDING FIGURES.

us. Many attempts have been made to study the problem. For modern civilized races there are data available which make this study precise. But for uncivilized and for ancient peoples few records exist. The Corpus inscriptionum latinarum of the Berlin Academy used by Macdonell[4] is perhaps the best of the ancient records, but even these records fail in their accuracy as the potential life period wears towards its natural close. Most other records consist of contemporary general statements which are, of their very nature, biased or refer more particularly to a restricted portion of the community. Or the impressions may be culled even more vaguely from the scant records of the ages at death of a few more notable persons of the time. The only way in which a correct assessment can be made is by wringing the secret from the bones themselves left immutable by time in the grave.

To this end we have addressed ourselves over a long period of steady and persistent work, using for this purpose the ever-increasing collection of material in the Hamann Museum. The observations recorded in this paper are founded upon the standards derived from this material.

METHOD OF INVESTIGATION

That time leaves its impress upon the skeleton is well recognized and it is usual to describe a skeleton as that of a child, an adolescent, an adult or a senile person. Beyond this rough discrimination it has hitherto been impossible to advance because of insufficient data. The singularly fortunate position of the anatomical laboratory of Western Reserve University has enabled us to progress further with assurance in the identification of age of skeletons. Ever since 1912, the policy of retaining intact the skeletons of all cadavera delivered to the medical school, together with the record of their age, among other valuable and essential data, has placed us in a unique position. At the time of writing this collection numbers some 1,400

[4] Macdonell, W. R., 1913, "On the Expectation of Life in Ancient Rome, and in the Provinces of Hispania and Lusitania and Africa." *Biometrika*, Vol. 9, pp. 366–380.

individuals of all ages and belonging to white and Negro stocks. For some years now we have been steadily publishing the results of our investigation upon the time record left imprinted on the bones, but it will require another decade to complete this work. Meantime the research has gone far enough to enable us who have the experience to indicate, with a fair probability of accuracy, the approximate age of any individual skeleton. By this statement I mean a probable accuracy of within five years distributed evenly two years on each side of the age estimate, provided that be sixty years or less. The accuracy is certainly less than this if the age is above sixty, for, toward the limit of the natural span, differentiating features become ever less pronounced and more erratic.

One can not give a full description here of all the details upon which our age estimate is based, but the general scheme is the following. Up to and including the age of twenty-five the union of epiphyses may be relied upon as an age indicator. It has been assumed, upon altogether insufficient evidence, that individual variation is so great that no real reliance can be placed upon epiphyses as an age determinant. Our quantitative studies emphatically deny this assumption. Part of this research has been published in the paper by Stevenson.[5] From twenty-five to thirty-five years the symphysis pubis gives a fair indication of age, and to the elucidation of the symphysial problem I have myself devoted a number of papers, the results of which are summarized in the one to which reference is here given.[6] Between thirty-five and fifty years changes take place in regular sequence at the articular ends of bones, at the muscular attachments and in the texture. This period has not yet been properly recorded in published form, but Graves has given, in a paper on the scapula, an adumbration of what will eventually be demonstrated.[7] At or about fifty years certain well-defined differences in texture and secondary changes on the surface of bones set in which have as yet been but lightly sketched in the papers by Graves and by myself. Suture closure has but a qualified value in this study. For white and Negro males the subject of suture closure has been adequately presented by Lyon and myself in various published articles (13).

The life history of the skeleton from adolescence to senility can be outlined in the following manner. From adolescence to the age of twenty-five years union of epiphyses is the dominant feature. From twenty-five to thirty years closure of sutures continues the tale along with the consolidation of areas, like the symphysis pubis, which possess rudimentary epiphyses. From thirty to thirty-five years the skeleton is at its prime and there is a lull in differentiation. Sutures not yet fully closed mark time, having lost their impetus to unite. During this period the muscular system and the cerebellum, the coordinating mechanism for muscular control, begin to show deterioration.[8] Such deterioration becomes indicated in the bones between thirty-five and forty-five years as an intensification of the sites of muscular attachment and as the formation of rims, not lipping, at the articular margins. The so-called muscular markings on bone are not an indication of muscular development and strength but appear when the muscular

[5] Stevenson, P. H., 1924, "Age Order of Epiphyseal Union in Man." *Journ. Phys. Anthropol.*, Vol. 7, pp. 53–93.

[6] Todd, T. W., 1923, "Age Changes in the Pubic Symphysis VII. The Anthropoid Strain in Human Pubic Symphyses of the Third Decade. *Journ. Anat.*, Vol. 57, pp. 274–294.

[7] Graves, W. W., 1922, "Observations on Age Changes in the Scapula." *Journ. Phys. Anthropol.*, Vol. 5, pp. 21–33.

[8] Ellis, R. S., 1920, "Norms for Some Structural Changes in the Human Cerebellum from Birth to Old Age." *Journ. Comp. Neur.*, Vol. 32, pp. 1–33.

system is on the downgrade, long after the time when current hypothesis would call for their maximum development. From forty-five to fifty years preparation is being made for the far greater changes occurring after fifty: the final rims are developed and the smooth and polished surface texture of earlier years begins to give place to a more granular appearance which after fifty, first in ribs and vertebrae but later spreading to all parts of the skeleton, is associated with a peculiar modification of bone substance which we describe as a cinder-like texture. Between fifty and sixty years the surface erosions progress, but from sixty onwards they may be more or less stationary though the cinder-like texture becomes more pronounced.

A subsidiary feature very well marked in skeletal history is the progressively increasing individual variation in appearance and progress of age change from thirty-five years onward. It is as though the rigorous control of differentiation by nature were little by little relaxed, the individual having, as it were, fulfilled the physical requirements for which he was ordained and being now a less desirable creature from nature's point of view. I do not mean to press this figure of speech: it suffices to clothe the impression which I wish to convey.

This field of investigation is virgin and affords so much opportunity for work that we must not be expected to set forth all our researches in detail for years to come. Until then determination of age will be largely the perquisite of those who have worked upon this material at Reserve alongside us and have learned by practical experience, covering a battalion of skeletons, how to interpret differences sufficiently obvious when studied by the quantitative method.

Age at Death in Roman Provinces

In 1913 Macdonell published a very important essay on the expectation of life in Rome and the Roman colonies in Spain and Africa, based upon data extracted from the Corpus inscriptionum latinarum of the Berlin Academy.[9] These Inscriptiones give the ages recorded on tombstones of the general population. It may be assumed that the records are not those of the lowest of the people though most often they refer probably to slaves and freedmen of the well-to-do classes in Rome and to a population of somewhat higher social status in the colonies. There is no conclusive evidence at present of the precise date of these records although they are all certainly within the first six centuries of the Christian era and mostly belong to the third and fourth centuries. It was Marcus Aurelius who first introduced official registration of births in Rome and the provinces. For astrological purposes also the age, especially the day and the hour, was necessary. The age of Christians is stated as a rule with greater accuracy than that of non-Christians. Many of the tombstones have the letters P. M. (plus, minus) prefixed to the age, especially when the age is given in multiples of five. This habit of stating age in multiples of five becomes more pronounced as individuals grow older and results in a jagged appearance of the curves (Fig. 2). It would be interesting to know if these provincials, especially those of Africa, were of Roman descent. As emigration of Italians is known not to have been great, and as many of the names are native in origin, it is probable that we are dealing frequently with the graves of people of local African origin. These are not Negroes but North Africans, Carthaginians and the like.

From the records summarized in the foregoing statements it is clear that the Inscriptiones give a fair idea of the mortality curves in Rome and the Roman colonies in Africa and Spain during the first three or four centuries A. D.

[9] *Loc. cit.*

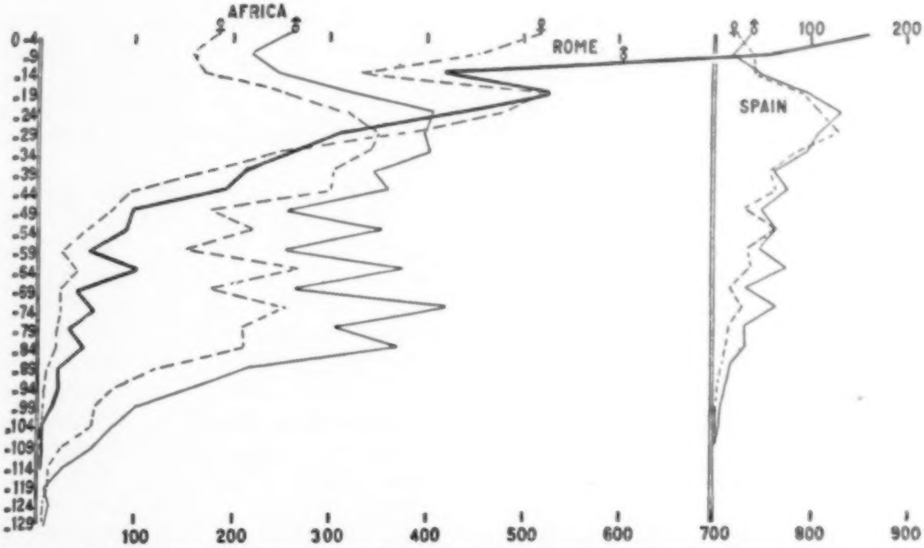

Fig. 2. Graphs of mortality for both sexes in Rome and the Roman provinces. Based on data gathered by Macdonell.[4] Ordinates in years of age: abscissae in lustra of five years. Note the early peak of maximum mortality and the increasing fluctuation after thirty-four years.

What may be the cause of the peculiar curve for Rome itself we need not pause to inquire. The curve is plainly abnormal and hence is of no moment for our present investigation.

The mortality curves for the African and Spanish colonies, on the other hand, bear the mark of approximation to normality. In both geographical areas the peak comes in the third decade for both males and females. It is important to notice that a saw-tooth character appears in both curves only at the end of the fourth decade. Up to this date the curves are regular; thereafter a significant fluctuation takes place which, it will be found, is matched in our own curves from the dissecting room. The only satisfactory explanation of this jagged character of the curves is a lack of precision in recording the exact age. While for astrological purposes the birthday is remembered, the year of birth becomes forgotten. This is sufficiently obvious in later years of life, even as it is to-day. One can not accept without question the statements of old age as recorded on the Inscriptiones which indicate a duration of life of about one hundred years as not uncommon, especially in Africa.

The peak which appears about sixty years in Spain and about seventy years in Africa must not pass unnoticed. Though not so high as the peak of the third decade it is high enough to indicate a second mode in the mortality curve. Whereas, in the light of data still to be presented, the earlier peak may be considered that of young or middle age this one must be regarded as the peak of old age.

Curves of Modern Middle Age Mortality

Attention should next be directed to the dissecting room curves. The population represented by the material in our anatomical laboratory can not by any stretch of the imagination be regarded as typical of the community. This sample is distinctly selected. Its

composition has been discussed in an earlier paper.[10] This is not a pure hospital population such as Pearson has studied,[11] for besides the regular hospital patients it contains relatively few victims of chronic diseases, but, on the contrary, includes many individuals who have met their death in sudden and violent manner through accident, by homicide and at their own hands. There has been no conscious selection by age. It may be assumed with some confidence that the series is a fair sample of the population of Cleveland which, through some inherent mental or moral inadequacy, is unable to make those adjustments necessary to a successful life in modern environment, "paltry victims to the spirit of mental and social restlessness that makes so many unhappy in these days."[12] In other words, they are the people to whom are denied the security of life and the comfort of living which are characteristic of our civilization.

Figure 3 gives the mortality curve of 445 white males delivered to the laboratory between 1913 and 1921. These records were collected for another research, namely, an investigation of cranial thickness: they can therefore have no bias favoring the present inquiry. Once again we see the tendency of the patient to give his age in lustra of five years, just as in the Roman mortality curves. The median of this series falls in the age of forty-five years, a rather significant fact, inasmuch as forty-two years contains the peak of death in Pearson's curve of middle age mortality (Fig. 1).

Figure 4 is the mortality curve for 250 male Negroes also delivered to the laboratory during the same period. Again appears the tendency to give the

[10] Todd, T. W., and Kuenzel, W., 1924, "The Thickness of the Scalp." *Journ. Anat.*, Vol. 58, p. 237.

[11] Pearson, K., Blakeman, J., and Lee, A., 1905, "A Study of the Biometric Constants of English Brain Weights and Their Relationships to External Measurements." *Biometrika*, Vol. 4, p. 125, also Greenwood, M., 1904, "A First Study of the Weight, Variability and Correlation of the Human Viscera. *Biometrika*, Vol. 3, pp. 64–65.

[12] Hardy, T., 1895, "Jude the Obscure." Ed. 1923. New York. p. 387.

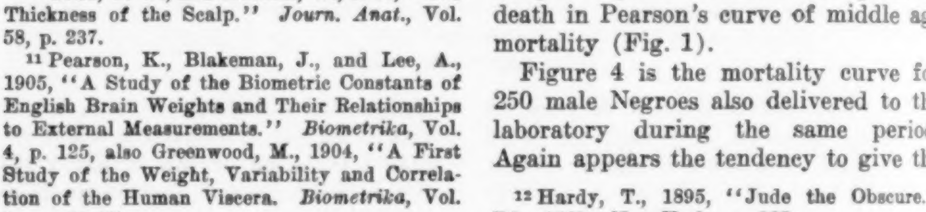

FIG. 3. MORTALITY GRAPH FOR WHITE MALES IN DISSECTING-ROOM POPULATION, CLEVELAND. ORDINATES, AGE IN YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE TENDENCY TO GIVE AGE IN LUSTRA OF FIVE YEARS. MEDIAN IN BLACK SQUARE.

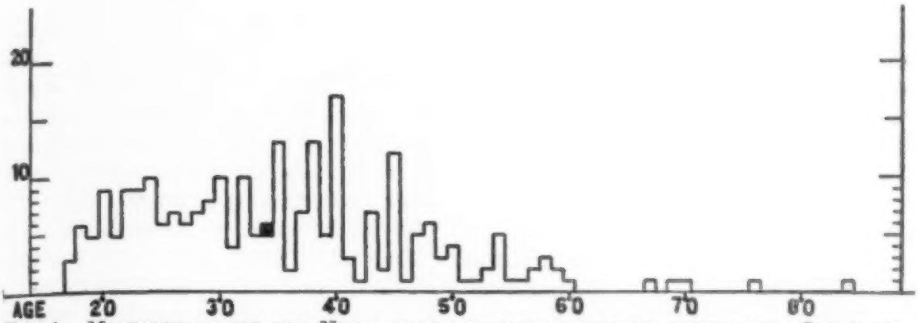

FIG. 4. MORTALITY GRAPH FOR NEGRO MALES IN DISSECTING-ROOM POPULATION, CLEVELAND. ORDINATES, AGE IN YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE TENDENCY TO GIVE AGE IN LUSTRA OF FIVE YEARS. MEDIAN IN BLACK SQUARE.

age in lustra of five years, though this is not so marked as among the whites, because the habit seems to develop after the age of thirty. The median of this series falls in the age of thirty-three years. I am not sure that the difference in position of the median from that of the white males is a true difference. It may well be that we have here a confusion due to the overlapping of a curve of adolescent death: for there are relatively many more Negro deaths in the third decade. The significant fact is that death in this population occurs relatively early in life. It is not a population of state-supported paupers, like the dissecting room material in England. There is here no indication whatever of Pearson's curve of old age death.

MORTALITY AMONG PRIMITIVE PEOPLES

I. *West African Tribes*

During 1925 I had the good fortune, through the courtesy of Sir Arthur Keith, to be able to study the series of skulls of West African tribes housed in the Museum of the Royal College of Surgeons in London. In this series are 189 skulls, excluding those of children. With some of them are definite records of sex and even of approximate age, but for the majority sex and age must be diagnosed by anatomical means. In several recent articles I have dealt with the age indication of suture closure.[13] The general plan of suture union seems to be a real progress of union from about twenty-two to thirty years, at which time there is a definite inhibition of progress. This is a slowing up of union, not a prohibition of further closure. As a result individual variation is so great that suture closure, especially on the exterior of the skull, can not be used as a very reliable age indicator: its evidence gives an approximate date only. Texture of the skull, on the contrary, is a more certain guide. So far it has proved impossible to set forth our experiences with skeletal texture in an intelligible manner; age estimation by this means is a matter of experience which can be demonstrated upon actual material. We usually make the estimate in lustra of five years.

Of the West African skulls in the College of Surgeons collection there are 108 male, 79 female and two of uncertain sex, it being understood that these figures are the outcome of my own estimation of sex, where that is missing from the record, and not necessarily the sex given arbitrarily in the catalogue. I have discarded the catalogue statements, as they record the appreciation of laymen or of

[13] Todd, T. W., and Lyon, D. W., 1924–25, "Cranial Suture Closure," Parts I, II, III, IV. *Journ. Phys. Anthropol.*, Vol. 7, pp. 325–384; Vol. 8, pp. 23–45, 47–71, 149–168.

medically trained observers with but little experience of the features of the Negro skull.

The result of my notes upon age of this West African population is recorded in Figure 5. The median specimen is indicated by the circle and falls in the lustrum ending at thirty years. This is rather striking when we recall that the median of the W. R. U. modern American Negro laboratory population falls in age thirty-three years. The peak of mortality falls in age twenty-five to thirty years. This again is striking in view of the fact that the peak of Roman Africa also falls in the third decade. Of course Roman Africa and West Africa are widely different areas and the inhabitants represent quite diverse populations. The really significant fact is that an earlier peak occurs among the West Africans in the third decade and another in the sixth.

Now it is impossible to exclude artificial selection among these skulls. Many skulls were chosen from cemetery material by the donors, and it is natural to suppose that these collectors would choose the skulls which seemed to them most "perfect." By this we must infer completeness of skull (not necessarily presence of the mandible), a good and relatively unworn dentition, and plain visibility of suture lines. It should, however, be remembered that native African skulls are apt to retain a good dentition throughout the majority of adult life, and also that suture lines on the exterior of the cranium do not obliterate early or completely as a rule. The bias would appear to be in favor of the young adult skull, and one may inquire if the peak during the third decade is not really a spurious result of artificial selection. It is my experience, however, that the skull which remains intact longest after burial is not that of the young adult, nor of the senile individual but that of the middle aged person, between forty and fifty years. Cemetery material is likely to yield far more of these skulls intact than those of younger or older people. Hence the collector's desire to obtain young skulls would be to a large extent neutralized by the material among which he would have to choose.

Turning now to another doubt which rises regarding such material, namely, the question of its origin, was it, for example, material from the bodies of warriors slain in battle? The answer to this is given in Table I shown below. It is not usual for an African tribe to give permission for the exhumation of its own people. The tribe will more readily accord permission for the rifling of a ceme-

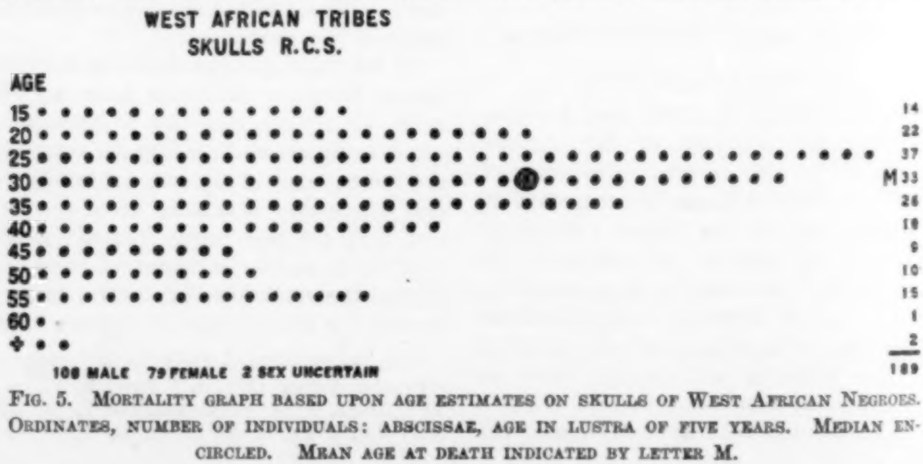

FIG. 5. MORTALITY GRAPH BASED UPON AGE ESTIMATES ON SKULLS OF WEST AFRICAN NEGROES. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS. MEDIAN ENCIRCLED. MEAN AGE AT DEATH INDICATED BY LETTER M.

TABLE I

West African Known Tribes

Royal College of Surgeons (including Barnard Davis collection)

Texture years	Sex unknown	Male	Female
15		2	12
20		14	8
25	2	21	16
30		21	12
35		16	10
40		9	9
45		6	3
50		6	4
55		10	5
60		1	0
60 +		2	0
Totals	2	108	79

tery of outlanders who have died on their territory during a trading journey. Somewhere in his writings Sir Harry Johnston records the observation that Negroes are only locally immune to the peculiar African diseases which are insect borne. If the native be transferred as little as sixty miles from his home he is susceptible just as are other foreigners to the locality. The relatively large number of females indicates that the sample is that of a general population, and the earlier peak of mortality in the third decade coincides in the two sexes. The later peak is not apparent in the females, probably because of the small number of individuals represented.

Despite its shortcomings this sample of native African humanity, being all we have as yet to guide us to a record of West African mortality, may be utilized with some confidence in a comparison like that upon which we are now engaged.

II. *Tasmanians*

Partly owing to the habit of cremation, but largely for other reasons, the recently extinct Tasmanians have left but few records of their physical features. The largest collection to-day is that in the College of Surgeons, which contains thirty-six skulls with a few skeletons. Of the skulls thirty-two are sufficiently complete to be used in this study. The collection includes a number originally belonging to Barnard Davis in whose Thesaurus craniorum[14] and in the official catalogue of the museum are descriptions of the finding and recovery of these skulls which vie with tales of adventure in thrilling incidents and suggestions. "I will not speak of our labours and dangers in the adventure: it was the painful occasion of the loss of two of our three boats with their crews of nine men," writes Dr. Archibald Sibbald, R.N., in 1854, presenting one female cranium to the museum,[15] a child of sixteen years, according to my observations. The worst of all records is that of cranium 1417 from the Barnard Davis collection in which it has the number 1121.

Dr. Joseph Milligan, "Protector of the Aborigines," gravely sets forth the details of the murder of this native, a man of thirty-five years according to the skull texture, by a nightmare ridden hut keeper in a record[16] equalled only by Du Chaillu's terrified description of the "ferocity" of the gorilla.[17]

Figure 6 gives the result of my study of age on this small population. Again the peak of mortality is early, occurring at fifteen years. The majority of deaths took place about or before twenty-five years, though there is suggestion of a second peak in the sixth decade. The sample is much too small for emphasis, but the curve is significant, to my mind, in that its peaks follow the general rule

14 Davis, J. B., 1867, "Thesaurus craniorum." London.

15 Flower, W. H., 1879, "Catalogue of the Specimens illustrating the Osteology and Dentition of Vertebrated Animals," Part I, "Man," pp. 201–202. London.

16 Davis, J. B., *loc. cit.* pp. 270–271.

17 Du Chaillu, P., 1861, "Explorations and Adventures in Equatorial Africa." London. pp. 350–352.

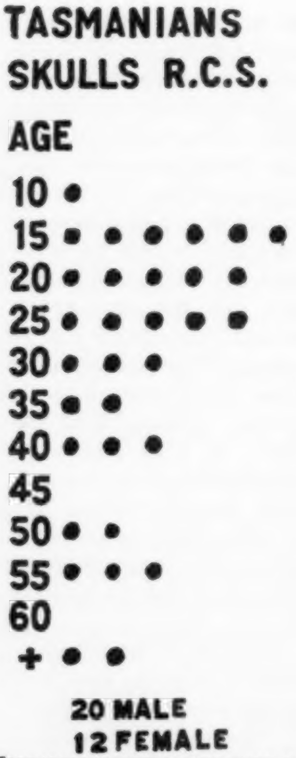

FIG. 6. MORTALITY GRAPH BASED UPON AGE ESTIMATES ON SKULLS OF TASMANIANS. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS.

observed so far in the observations set forth in this paper.

The details by sex are given in Table 2. In view of the greater resistance offered to decay by skulls of forty and more years, it is quite remarkable to find so many young crania.

MORTALITY IN ENGLISH POPULATIONS

I. Bronze Age. Furness

Through the kindness of Mr. William Atkinson, of Ulverston, I had the opportunity, in 1925, of examining the remains of sixteen individuals of the Bronze Age in a disc burial on Birkrigg in Furness. Though the remains were scanty and my time short it was sufficiently evident that the age of all sixteen

TABLE II

TASMANIANS

Royal College of Surgeons (including Barnard Davis collection)

Texture years	Sex unknown	Male	Female
10		0	1
15		2	4
20		4	1
25		3	2
30		2	1
35		2	0
40		2	1
45		0	0
50		1	1
55		3	0
60		0	0
60 +		1	1
Totals	—	20	12

persons ranges from seventeen to thirty years; there were none older than this. It is by no means my intention to suggest that Bronze Age people did not live to a greater age. I merely desire to record the experience at this one particular burial, the only site which fortune enabled me to visit.

II. The Scarborough Medieval Community

"In a plot of ground half-an-acre in extent, on the seaward extremity of Scarborough Castle Hill, are three quite distinct types of ancient remains: a Bronze Age village, a Roman signal station, and no fewer than three chapels, one earlier and two later than the Norman Conquest."[18]

Mr. F. G. Simpson, who explored the area with a thoroughness and precision of detail most inspiring in its nature, was kind enough to take me over the site and expound the results of his work. At the same time Sir Arthur Keith and Miss M. L. Tildesley, in whose charge the skeletons now are, at the College of

[18] Collingwood, R. G., 1925, "The Roman Signal Station on Castle Hill, Scarborough." Printed for the Corporation of Scarborough by E. T. W. Dennis and Sons, pp. 1–8.

Surgeons, permitted me to examine the remains at my leisure. Of these one hundred and forty-three were suitable for my purpose and with Miss Tildesley and Miss George I made a record of the skeletal age of each. The bones on which we were able to make notes dated from the eleventh, twelfth and thirteenth centuries. One of the most striking features of the skeletons was the fact that tooth wear gave no indication of age. Indeed it is possible to separate the skulls into two series, one showing little wear and the other relatively considerable wear of teeth at identical ages. I am led thus to believe that we encountered, in this site, either two grades of society or a marked reduction in the coarseness of food during the two hundred years or more represented by the skeletons. The former theory has probably more to support it than the latter. Once again we estimated texture ages in lustra of five years.

Figure 7 gives the mortality record with the total numbers for each lustrum at the right-hand side. Of the young children it was impossible to make an adequate study, but our records show a peak in childhood in the second lustrum, an adolescent peak at nineteen, a middle-age peak early in the fifth decade and the suggestion of another late in the sixth decade. There is no peak of old age. Granted that senile skulls do not weather so well as those of middle age, the theory of accident will not account for the relatively small number of aged members of the community, for in this series the skeletons were preserved also in very many instances. We must conclude then that few individuals reached advanced years. The median of the series falls in age thirty-five to thirty-

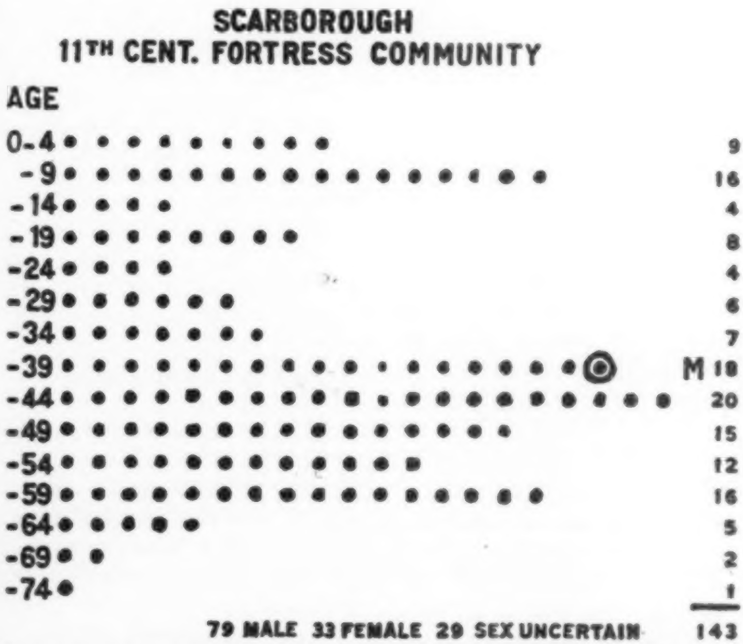

FIG. 7. MORTALITY GRAPH BASED ON AGE ESTIMATES OF SKULLS AND SKELETONS INDEPENDENTLY OF MEDIEVAL ENGLISH COMMUNITY AT SCARBOROUGH. ORDINATES, NUMBER OF INDIVIDUALS: ABSCISSAE, AGE IN LUSTRA OF FIVE YEARS. MEDIAN ENCIRCLED. MEAN INDICATED BY LETTER M.

nine years. There is a suggestion of a plateau from the fourth to the sixth decade, as most deaths occurred during this phase of life.

As a check on these anatomical observations just recorded we may turn to the pages of Montaigne. But it is to the Florio edition that we must refer in order to get the requisite flavor: the new Ives translation, literal and laborious, prejudiced by unwarranted assumptions, will only mislead in these passages. Miss Norton and Mr. Ives make the curious inference that in speaking of the age to which ordinarily a man might hope to attain, Montaigne wrote in disregard of contemporary facts. Whatever qualifications these authors otherwise show, the student of Montaigne, with the context of the Essayes before him, will have to discount their straining at the text on age.[19] "I was borne," writes Montaigne, "betweene eleven of the clocke and noone, the last of Februarie, 1533. . . . It is but a fortnight since I was thirty-nine yeares old. I want at least as much more." Then continuing, addressing himself, he writes, "Thou has already over-past the ordinarie tearmes of common life. And to prove it, remember but thy acquaintances and tell me how many more of them have died before they came to thy age, than have either attained or outgone the same: yea and of those that through renoune have ennobled their life, if thou but register them, I will lay a wager, I will find more that have died before they came to five and thirty yeares, than after."[20]

And again, in treating of age, Montaigne writes, "To die of age, is a rare, singular and extraordinarie death, and so much lesse natural than others. It is the last and extremest form of dying . . . an exemption, which through some particular favour, she [Nature] bestoweth on some one man, in the space of two or three ages!"[21]

With these significant words of Montaigne ringing in my ears and fresh from the Scarborough skeletons, by a rare piece of good fortune I encountered Mr. Harold Hulme, then of Cornell University Historical Department, at work in the British Museum upon the records of members of Parliament between 1604 and 1629 A. D. Mr. Hulme generously allows me to quote from his unpublished researches.[22] I have therefore drawn up Table III to demonstrate the age of political activity during the early Stuart period.

TABLE III

AGES OF MEMBERS OF PARLIAMENT
1604–1629
(Harold Hulme)
Of 825 known members there are records of age of 427

Age	Number
20–30	93
31–40	133
41–50	102
51–60	52
60 +	27

Under 25 years 61 members.

The peak of activity comes in the fourth decade, and there are nearly as many members under thirty years of age as between forty and fifty. The falling off after fifty is marked and the number under twenty-five years is significant.

[19] Montaigne, M., The essays of. Translated by George B. Ives, introductions by Grace Norton. Cambridge, U. S. A., 1925, Vol. 1, p. 105, Vol. 2, pp. 34–5.

[20] Montaigne, M., "The Essayes of Michael Lord of Montaigne done into English by John Florio with an introduction by Thomas Seccombe, the first booke," London, 1908. Vol. 1, pp. 77–78.

[21] *Id.* Vol. 1, p. 450.

[22] Hulme, H., "Members of Parliament 1604 to 1629," (unpublished: personal communication).

The relative youth of these members of Parliament must not be dismissed as misleading on the ground that in Stuart times the modern secret ballot was unknown. Nor must it be concluded that the positions were hereditary. The majority of the elections were genuine contests. Farmer and agricultural laborer did not exercise the franchise, but the yeoman freeholders held very important the privileges of Parliament and the principle of no taxation without representation. Trevelyan[23] (pp. 10–105) gives a very clear and impressive account of the parliamentary elections and methods of the time and I derive this synopsis from his statements. Gentry and burgesses shared between them the representation of the country, and at election time knights, squires and baronets courted the yeomen hat in hand on market days, seeking votes for their return to Parliament. Some 400 members sat for the towns, and but ninety-two for the counties. Yet since many boroughs chose country gentlemen as their representatives there was not in practice the disproportion between town and county which would appear in theory. In the official returns of each Parliament 350 out of the 400 borough members are styled baronets, knights, squires and gentlemen as against a couple of score or so aldermen, merchants and mayors. A certain number of boroughs in the Cornish villages were in the hands of the Crown or of private land owners but in the seventeenth century the proportion of these non-elective boroughs was not large. Corruption of voters by money also was not so general as it afterwards became. In many cases the English burghers preferred to look for a representative outside their own class. Hence taking into consideration all the available information we may justly conclude that the age distribution of these members as recorded by Mr. Hulme does give a substantially correct impression of the active age of manhood in the first quarter of the seventeenth century. It is probably more accurate for our purpose than the records of earlier or later parliaments up to the reform of the ballot in the earlier part of last century.

Thus the straws of evidence all point in the one direction. The peak of old age death, so prominent in modern mortality curves, fades into insignificance the further we recede from the present day and in the dimmer records of the distant past we find no real indication of its existence.

Mortality in Pecos, New Mexico

In recent years Dr. A. V. Kidder has been employed upon excavations on the Pecos site in New Mexico. Through the kindness of Dr. Kidder and Dr. Hooton, in whose charge the skeletons from Pecos lie in the Peabody Museum of Harvard University, I was permitted to examine this magnificent series of remains from 594 individuals, the dates of whose lives range from 800 to 1800 A. D. No other collection to which I have had access surpasses this one for completeness of skeletons, precision of data, and thoroughness of care. It is a monument to archeological efficiency. The skeletons are segregated into periods by the glazes on the pottery. Later I hope to analyze the records of the life period at the different dates indicated by these glazes. For the moment, however, our needs are fulfilled by the information given in Figure 8.

With the energetic and capable help of Mrs. Ethel Clarke Yates and Mr. George L. Williams, I assessed the age at death of these approximately six hundred skeletons and the record shows admirably the successive peaks of mor-

[23] Trevelyan, G. M., 1904, "England under the Stuarts," London and New York.

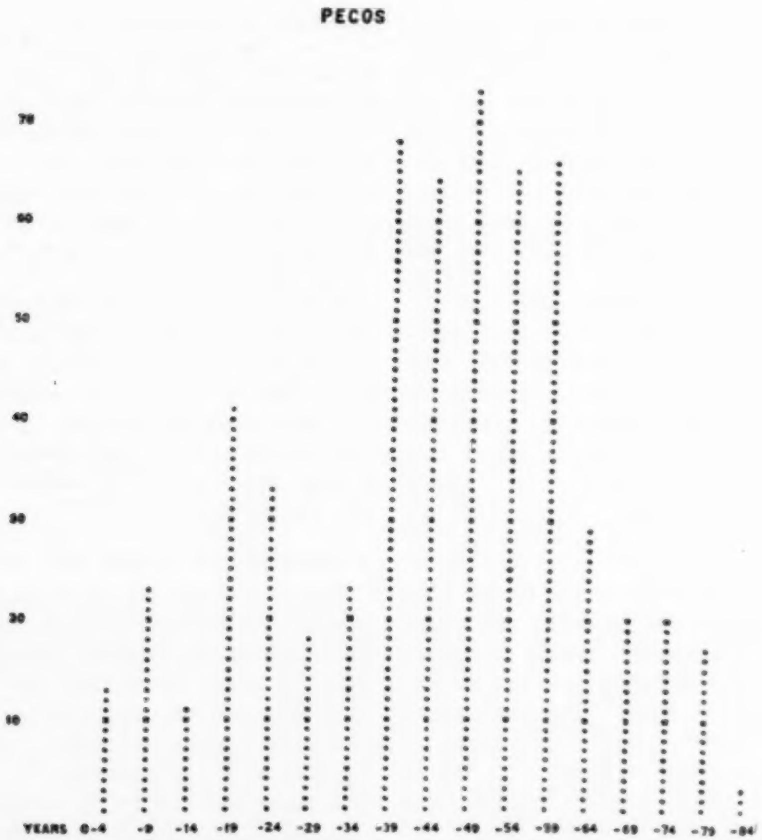

FIG. 8. MORTALITY GRAPH BASED ON AGE ESTIMATES OF SKULLS AND SKELETONS FROM THE PECOS SITE IN NEW MEXICO. ORDINATES, AGE IN LUSTRA OF FIVE YEARS: ABSCISSAE, NUMBER OF INDIVIDUALS. NOTE THE PLATEAU AROUND THE PEAK OF 45–49 YEARS.

tality. The very young children are represented by such scattered remnants that, as usual, they must be discarded. Hence our first peak falls in the second lustrum. The adolescent peak between fifteen and nineteen years is quite striking. After that there is a plateau from the later part of the fourth to the later part of the sixth decade with the median skeleton falling into age forty to forty-four years. After the sixth decade the number of deaths falls off rapidly and old age shows no peak.

Over the thousand years represented by this series there is no indication that life to old age was anything but an exception.

CONCLUSION

The inference to be drawn from these several studies seems very clear. The various peaks of mortality coincide pretty well throughout the investigation and they reproduce fairly the several peaks into which Pearson has analyzed our modern mortality curve. The commanding peak of middle age death is not accounted for by the accident that skulls of forty to fifty years weather better than others, for this peak is confirmed by the skeletons as well as the skulls.

In the times when Rome imposed her peace upon the civilized world, there is evidence of frequent survival to old age, but this peak of senility is quite lacking in the troubled times of medieval England and the little known native culture of the American continent.

In the native populations of West Africa and, so far as we have evidence, of Tasmania, the peak of mortality occurred at a relatively early age, but this has its reflection in the early peak of our Negro population of the dissecting room.

The peak of middle age death for populations other than those of Africa and Tasmania occurs in the early part of the fifth decade and this again finds parallel in our white dissecting room population.

Obviously, the modern series of the Western Reserve anatomical department give no indication of actual duration of life in the general population of the country but rather represent that stratum of society subjected to hazards in many ways comparable with the risks of the medieval and native populations which have been investigated.

The superficial observation that, among native tribes, old men are often encountered has no bearing on this problem. It is natural to put forward the patriarchs with their accumulated wisdom when strangers are in evidence or bargains are to be made. We must not let this human impulse blind our eyes to the naked record of the bones. "And the Lord commanded Moses concerning the Levites, saying . . . and from the age of fifty years they shall cease waiting upon the service and shall serve no more."[24] Perhaps our best evidence will always be, at least for those generations long since gathered into oblivion, the evidence of the skeletons which Time has not effaced. At least the possibility of reconstructing once more something so intimate in the life of these lost centuries as the record of mortality gives us a closer link with those who have passed before us along the pathway of humanity.

Trevelyan[25] concludes his delightful work with an inspiration aptly fitting the mood in which we must draw this record also to a close. "The more honestly we attempt to compute the number and quality of the things wherein the value of life consists even in our own generation, and at our own doors, the more complex and difficult does such a calculation appear. How much less, then, shall we be able to pluck out the innumerable secrets of the past, count them, weigh them, and so find the total value of some dead century. What we know is indeed an infinitely small part of what has been; but it is all that is left us now and by it we can still escape in imagination from the decree passed against each of us at his birth, that he should not issue forth from his narrow space of years, with its little circle that looks so large, of modern thoughts and sights and sounds." . . . Through these poor skeletal records, as through Trevelyan's sages and poets, heroes and martyrs of history—"through these alone can all the dead live so that the living may see them where they stand."

Summary

(1) By the examination of skeletons it is possible to estimate the age at death of ancient or primitive populations.

(2) The chief difference between these peoples and civilized populations of to-day is the apparent fact that the peak of old age death is a comparatively modern achievement resulting from greater safety and improved conditions of living.

[24] Numbers, VIII, 25.

[25] *Loc. cit.*, pp. 516–7.

(3) The difference between the peaks of mortality in primitive and ancient people on the one hand and of modern civilized humanity on the other is roughly thirty years.

(4) This difference does not indicate a prolongation of the potential duration of life which undoubtedly remains stationary through the ages.

(5) In modern populations, even in civilized communities, drawn from the lower strata of society, the old age peak characteristic of to-day is not to be found, owing to the relatively great hazards of life to which these unfortunate people are exposed when not sheltered by specific social legislation.

THE STUDENT OF NATURE[1]

By Dr. PAUL R. HEYL
BUREAU OF STANDARDS

The long life of Sir Isaac Newton comprised many different activities. For a brief period in his early years he practiced alchemy, being engaged with a relative in the search for the philosopher's tincture. Though never in holy orders, he devoted considerable attention to theology, and was a forerunner of the modern school of "higher critics." For the last thirty years of his life he was an important and highly paid official of the British government—the master of the mint. He was a good citizen, active in the defense of the traditional rights of the universities against political encroachment. But for none of these is he remembered to-day. Hundreds of men have equalled or excelled Newton in such respects, and all have been swept by relentless time into the limbo of mediocrities.

It is a matter for the instruction, reproof and correction of the materially minded to reflect that he to whom we are met to do honor is remembered for that period of his life when he was one of a class to-day often despised and rejected of men—a college professor, and withal for some years so straitened in circumstances that because of his inability to meet his payments to the Royal Society "it was agreed to by the council" (in the quaint language of the old record) "that he be dispensed with, as several others are." It is to be added, however, that he was later reinstated and that he served the society as its president for the last twenty-five years of his life. But it was during this period of narrow means and social obscurity that Newton accomplished the work which has made his name immortal. It is as a student of nature that he is remembered, and it is as fellow students of nature that we do honor to his name.

And what is there so remarkable about the study of nature that it should confer such distinction upon its devotee? Perhaps if we were suddenly called upon to answer this question we might hesitate. It may therefore be worth our while to devote a little time to the observation of the natural history and habits of this particular human type as illustrated by the concrete case of Newton.

How does this type originate? What are the predisposing causes which lead one to take up the study of nature? This question is difficult to answer because in so many notable cases the student does not consciously "take up" the study at all. It frequently seems to be a matter of predestination. Maxwell showed his bent almost before he could talk plainly; and in Newton's case this precocity was the more evident because of the absence of scientific suggestion in either his heredity or his environment as a child. He was the son of a small farmer, and it was originally intended that he should follow his father's occupation. The school curriculum of his day was composed principally of Latin, which was so little to the young Newton's taste that he was for a time regarded as a dull boy, perhaps the more so because he spent much time in the construction of windmills and mechanical toys; but he later lived down this reputation and stood well in his classes. It is as natural for a Newton or a Max-

[1] Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

well to turn to the study of nature as it is for a duck to swim, an artist to paint or a poet to sing.

It is told of Newton that when he was in his fifteenth year it was his mother's custom to send him to town on market days in the company of a faithful family servant. Such a trip to a normal country boy usually means a day of excitement and pleasure; but how did the young Newton spend his time in town? He allowed the servant to attend to the errands which occasioned the trip (as indeed most boys would have done) but he spent the precious hours of the day, oblivious to the attractions of the village, among the books of the local apothecary.

The fascination of nature for the child is understandable. Every one of us is born into a wonderland, and our endless questions about what we see sometimes try the patience of the adult and often exceed his ability to answer. And the mature student of nature is characterized by the retention to a remarkable degree of certain of the mental characteristics of the child: his fresh wonder, his insatiable curiosity. Such a one never becomes blasé. To the end of his days he is keenly sensitive to the wonder of the commonplace. Even so simple a phenomenon as the falling of an apple from a tree may start within him a train of thought which may lead up to a great generalization, such as the law of universal gravitation.

The childlike side of the student of nature is well illustrated by the story told of Faraday by a visitor who happened to be present when the scientist had reached a successful conclusion to his experiments on electrodynamic rotation. The visitor tells that when Faraday saw the current-bearing wire revolving about the pole of the magnet he executed a childish dance of delight around the table and insisted that his visitor should accompany him forthwith "to Astley's and see the performing horses."

That the motives of the student of nature are in part instinctive and childlike is, I think, well understood by people in general. This is one reason for the amused tolerance or even contempt with which he is regarded in certain quarters. But when the student of nature becomes a man, though he may not altogether put away childish things, he adds to them the rational motives of the adult. For this he sometimes receives scant credit. "Will you tell me," asks some one, in a wondering or perhaps contemptuous tone, "why a man of your abilities should spend his time as you do when he might be making real money at a man's job?" The scientist frequently allows such a question to go unanswered, because he realizes that if the answer could be understood the question would probably not have been asked. Sometimes when questioned thus he will direct attention to the occasional important practical application of his researches, though he does not regard this himself as a complete explanation of his own conduct. He may hand out this answer as an *argumentum ad hominem*, but as nothing more. Equally unsatisfactory is the explanation sometimes advanced for him that the scientific man is actuated primarily by the desire for fame, for the approbation of his fellows. Both this and the practical motive have place in the psychology of the student of nature, but he knows in his own soul that if the progress of science had depended solely upon these incentives it would never have reached its present state.

It is true that there is in the mind of every scientific worker a very human enjoyment of the pleasure of the game. With each obstacle overcome, with each difficulty resolved, we feel our muscles growing, and we rejoice as a strong man to run a race. But potent as this motive

may be and omnipresent as it is, the thoughtful student must admit its essentially selfish character; and when we ponder over the nature of the phenomenon we are endeavoring to explain the conviction is borne in upon us that nothing selfish is either deep or broad enough to account for it. The most potent motive actuating the student of nature, as in fact nearly every one else, must be idealistic.

One motive of this description is illustrated by Newton's case and by other scientific workers that might be mentioned, particularly Faraday. Newton's mind was of a distinctly religious cast, as his writings show. Such a mind finds much in the aspect of nature to nourish and foster this religious feeling, and conversely finds in its own point of view the justification for its efforts; for to such a mind the unraveling of the secrets of nature is but following the thought of God, the fulfilling of the chief end of man. To such a mind no other motive appears necessary; yet the student of students of nature must recognize that this is not the whole story, even in Newton's case.

There are many scientific men to-day in whose mental make-up the religious motive (at least in the traditional sense of that term) seems to play but a minor part. In some extreme cases it appears to be altogether absent; yet such types are just as zealous and industrious in the study of nature as their more patently religious brethren. For the motives actuating such cases we have still farther to look.

Newton's greatest scientific production, that for which he is chiefly remembered to-day, is undoubtedly the Principia, the "Mathematical Principles of Natural Philosophy." And what was Newton's object in writing this work? Not primarily the greater glory of God, though its pages are not without devout reference; the motive of the book is obvious to the most casual reader: the reduction of all the phenomena of mechanics, terrestrial and celestial, to law and order and, so far as possible, to a single cause—gravitation; in other words, the explanation of nature.

So deep has been the impress made by this work upon subsequent scientific thought that it is hard for us to-day to put ourselves in the mental position of scientific students prior to its publication. Such students there were, and they were by no means lacking in acumen, but the sum of their accomplishments amounted only to a number of isolated facts and a few shrewd speculations.

Kepler had discovered by his studies of Mars that a planet moves in an ellipse with the sun in one focus, and that the radius vector drawn from the sun to the planet sweeps out equal areas in equal times. Later, he announced the law connecting the distance of a planet from the sun with its time of revolution to its orbit. But these laws as stated by Kepler were merely observed facts with no correlation and no satisfactory assigned cause. Horrocks, one of the two first observers of a transit of Venus, had in a vague way suggested that possibly the earth's gravitation might reach to the moon, but he offered no demonstration of it. The inverse square law of gravitation had, it seems, prior to the publication of the "Principia" occurred to at least three contemporaries of Newton. But Newton possessed what was lacking in these others—vision, a broad mental grasp, a good sense of perspective. He was able to visualize all moving bodies in the universe, from comets to falling apples, and to reduce them to a few laws, which in turn he showed to be corollaries of a single cause—gravitation.

How thoroughly this task was accomplished is evidenced by the change in the mental attitude of scientific men since Newton's day. The "Principia" is

taken for granted; the picture of the universe there set forth is part of our common heritage, almost innate. Newton succeeded in endowing all scientific posterity with that vision and perspective which he alone possessed in his day. By the hands of Newton we have been lifted and placed upon a peak which he himself could not reach, from which, like Moses of old, we may look over the Promised Land, though it may be reserved for those who follow us to enter.

Nearly two centuries later a similar crystallization and correlation of disjointed facts in the biological realm was brought about by Darwin with the publication of the "Origin of Species"; and the present state of physical science is again one of such bewilderment, such wealth of uncoordinated detail that the time is ripe for another such genius as Newton to make his appearance. Even Einstein does not go far enough; and Planck, with his quantum theory, has up to the present succeeded only in making us feel worse before we feel better.

To explain the universe! Is not this the characteristic and fundamental motive of all students of nature? It is true that in attempting to do this there have been advanced some explanations that were fantastic, and many that were incorrect or incomplete. To Ptolemy succeeded Copernicus, and to Copernicus, Tycho and Kepler, Newton and Einstein, and still the task is unfinished. But however diverse the explanations offered, the driving force of all these students has been the same. The universe is a riddle, a challenge to the intellect; and the human mind will not tolerate such a challenge. The gauntlet is picked up and the fight is on.

No motive is more widespread in humanity. In the presence of the great realities of nature the first impulse of man, whether savage or civilized, naïve or sophisticated, is to wonder; the second to guess at a cause.

Though the task before him is colossal, mere size or complexity has no terrors for the student of nature. He is perfectly aware that probably neither he nor his descendants to the third or fourth generation will complete the work. He has no assurance that it will ever be completed. Perhaps—who knows?—some great catastrophe, some celestial collision may extinguish all life on earth before the task is half done. And even if the end be accomplished, what good will it do? Will the men of that day be any happier? Will death be swallowed up in victory? But all such objections, when addressed to the student of nature, fall on deaf ears. He hears only the continual challenge: "Explain me!"—and the taunt is enough to spur him to the utmost. Because no motive could be more idealistic, no incentive could be more powerful. The human mind is proud and will tolerate no defiance.

It is said that at one time an astronomer discovered a new star, which he found to be approaching the earth with a great velocity. He calculated that it would strike the earth in a few months. He did not announce his discovery, fearing to witness the orgy of lawlessness and despair into which it might plunge the world. Night after night he studied this approaching doom, fascinated by it. One night he spoke aloud and addressed the star as follows:

> I know that you will soon destroy me and all life on earth; but I can calculate the day, nay, even the hour when this will happen, while you are but a blind, brute thing, and I would not change places with you!

For this proud attitude there is indeed much justification. The success of man in unravelling the phenomena of nature has been truly remarkable. As mystery after mystery shows itself to be more or less amenable to reason and consistent with the laws of thought we are encour-

aged to believe that nature as a whole may not be beyond our eventual comprehension. The student of nature is ever optimistic.

But against this optimism there is a barrier set up by certain philosophers. We must carefully distinguish, they tell us, with the tone and manner of a physician applying a cold compress to an inflammation, between explaining and merely describing. With the latter, they concede, we may go far, but ultimately explaining anything is a different matter. No amount of description is equivalent to the simplest explanation. The difference is one of kind, not of degree. We may know much about the *how* and nothing whatever about the *why*.

Herbert Spencer, more than half a century ago, laid down the dictum that the reality which underlies phenomena is utterly and forever unknowable to us. Many philosophers since his day have repeated and reiterated this doctrine. The ultimate aim of science, they tell us, is description, not explanation, and in support of this assertion they quote Newton himself ("Principia," Book III):

> Hitherto we have explained the phenomena of the heavens and of our sea by the power of Gravity, but have not yet assigned the cause of this power. . . . But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses.

But while Newton in his formal and official utterances confined himself to the description of the *how*, his correspondence shows that privately he speculated freely on the *why*, as every scientific man should. There is extant a letter from Newton to Boyle, in which he lets his fancy free as to the why of gravity. Philosophers may smile at it, and call it but a glorified *how*, but the fact remains that Newton set no limits to his private thinking. If he chose to speculate as to the *why*, he did so, however abortive the result. As Browning says, "A man's reach should exceed his grasp."

Spencer's dictum of the Unknowable, as Norman Campbell says, is met by many scientific minds with a spirit of rebellion. It is admitted that in spite of our earnest efforts we have up to the present made no progress whatever in the explanation of the *why*, but it is not admitted that present failure demonstrates future impossibility. Nothing, in my opinion, would more effectually wet-blanket scientific progress than a general and cordial acceptance of this doctrine. Personally, were I satisfied that the mind is incapable of reaching an ultimate explanation of nature, I would not spend another day in the blind alley of descriptive science, but would abandon it forthwith, and turn to something which might hold out some promise of satisfying the soul.

But is such an attitude reasonable, or is it purely sentimental? Perhaps there may be more reason in it than a superficial examination would lead us to suppose. Our concept of the mind to-day is quite different from that which was current sixty years ago. In Spencer's day introspective psychology, or "mental philosophy," as it was then called, had, as was thought, pretty well explored the phenomena of consciousness, which were then regarded as constituting the whole territory of mind. The modern view is that our consciousness is but a secondary part of the mind, floating as it were on the surface of a great deep of unconscious cerebration, whence come all our ideas, as bubbles rise and burst at the surface of a liquid in which some ferment is at work. Who is there who has not had at least one experience of the working of this mysterious power? Perhaps we have puzzled for days over a difficult problem, only to lay it aside from pressure of other things; and lo! when we are least expecting it the long-

sought solution wells up in the mind. Newton must have had many experiences of this kind. He was once asked by what mental process he arrived at his discoveries. His answer was that they were usually the result of "intending his mind" continually on the subject and waiting for it to unfold. And when the solution finally reveals itself the student of nature feels as though he were on the crest of some mighty wave, borne along without conscious exertion, he hardly knows whither. So great are the unexplored possibilities of the mind as we recognize it to-day that it is no longer safe to set metes and bounds for it.

We stand in a dark room, developing a photographic plate. For some seconds nothing appears; then high lights begin to come up here and there, showing as dark patches with no apparent logical connection between them. As the development progresses correlations begin to appear among these patches, and eventually the plate shows one pattern of law and order over its entire surface.

But the most wonderful part is yet to come, for the completed picture presents to the eye an appearance of perspective, of solidity. Your *á priori* philosopher might have argued that this would be an impossibility—that the picture contains but two dimensions and can not possibly present the impression of three; but he is reckoning without his host. He is not including the mind which reads this element into the flat picture.

In our study of nature we have hardly begun the development of the plate. Patches of correlated phenomena appear here and there, but the gaps between them are yet to be bridged over. And with complete development we shall have but the *how,* a logical description of the phenomena of nature and their interrelations. And then—who knows?—perhaps this wonderful mind-power may read into the finished but flat picture the transcendental element of the *why*—the ultimate explanation of nature. Obviously this can not be looked for until the development of the *how* is far advanced, perhaps fully completed; but what matter? The student of nature, as we have seen, is not actuated by selfish motives, but by something far more powerful, of an idealistic character. What though we shall never live to see the final victory? Like Simeon in the temple we may say: "Lord, now lettest thou thy servant depart in peace . . . for mine eyes have seen thy salvation."

Yet even with this great goal in mind, and a realizing sense of the colossal magnitude of the task, the student of nature is sometimes discouraged because progress seems so slow. A lifetime of patient effort yields often but a pitiable handful of results. Newton himself was not free from this feeling. He once compared himself to a child gathering pebbles on the shore of an infinite ocean.

But a man is not always the best judge of his own achievements. Time is required to bring a true sense of value and perspective, and after two centuries I think we may safely say that in this respect Newton much underestimated his own case. He did far more than collect isolated facts; he correlated these facts and bequeathed to his successors a permanent economy of thought. He smoothed the road as far as he went that others might run where he slowly crept. He said of himself: "If I saw farther, 'twas because I stood on giant shoulders." Modesty perhaps forbade his stating the corollary which his keen mind could not help but see: that corollary the fulfillment of which has brought us together two centuries later to do honor to his memory.

We often build better than we know. There is a delightful story to this effect in the ancient myths of our Nordic race, which for its human interest and its philosophy is worthy of being placed beside that other story which has come

down to us from the ancient myths of our Semitic brothers and which tells of the first pair in a garden. And because I feel sure that the first tale is not as familiar to you as the second I am going to give myself the pleasure of telling you the story of "Thor's Journey to Jötunheim."

In the ancient city of Upsala, in the olden time, there was a temple to Odin, the chief of the gods. The king of the giants, Utgardeloki, whose race was at eternal warfare with the gods, hated Odin and, wishing to insult him, destroyed the temple and extinguished its altar fires.

When Odin heard the news he summoned a council of the gods to meet in Asgard, the home of the gods, and to this council there came among the others, Thor, one of the twelve sons of Odin.

Thor was the god of thunder. His home was not in Asgard but in Thrudvang, the storm-cloud. When he knit his brows the lightning flashed from his eyes; when he spoke it was as the roll of thunder in the heavens. In his hand he carried his magic hammer, Mjölnir, the crusher; about his waist he wore a belt of the kind possessed only by the gods, which when tightly drawn conferred strength upon the wearer.

At the council of the gods Thor's voice was raised for immediate warfare against the giants, but in this he was not supported by others, and the council broke up without anything definite having been decided upon. Thor, angered by the indecision of the council, decided to take matters into his own hands and to go to Jötunheim, the land of the giants, seek out the giant king, Utgardeloki, and punish him for the insult to his father Odin. He made no public announcement of his purpose, but left Asgard secretly. Over the rainbow bridge he went, from Asgard, the home of the gods, to Midgard, the abode of men, where he wandered for several days seeking the road to Utgard, the abode of giants. Finally, one day as evening came on he found himself lost in a forest. However, he happened to spy a curiously shaped house, without windows and with but one door which took up the whole of one side of the house. The house being empty, he spent the night in its shelter.

The next morning Thor felt the ground shake as from the tread of some great creature, and suddenly through the morning mists he saw loom up the figure of a huge giant. Thor grasped his hammer, but on second thought laid it down again, thinking that the giant might direct him to Jötunheim. The giant, not noticing Thor for the moment, said "Ah, here is my mitten!" and stooping he picked up the house in which Thor had spent the night. As he did so he noticed Thor and called him by name, saying, "I know you, Thor, by your belt and by the hammer which you carry; but what are you doing here?"

Thor replied that he was seeking the road to Jötunheim, as he had a mind to pay a visit to the giant king, Utgardeloki.

"In that case," said the giant, "we are well met. I serve Utgardeloki in giant-land and I am now returning thither. If it pleases you, we may journey together. My name is Skrymir."

Thor was glad to agree to this, and the giant continued:

"Since we are to travel together, we may as well put all our provisions in this wallet of mine, and since I am the bigger and the stronger of the two, you will permit me to carry the load."

The giant then threw the wallet over his shoulder and the two started on their journey. The giant at first attempted to dissuade Thor from his purpose, saying:

"You think I am big, but you will find others in Jötunheim bigger than I.

I know of the ancient enmity between your race and mine, and I fear trouble if you carry out your purpose of making a visit to our king. A very small happening may cause the old feeling to flare up. No good can come of your visit, and I hope you will abandon your purpose."

But Thor was not to be dissuaded, and the giant soon gave over his attempt.

They journeyed all that day without getting out of the forest, and when night fell the giant, declaring that he was too tired to eat and wanted only to sleep, threw the wallet to Thor, saying that he had better get his supper and a good night's rest, as there was a hard journey before them on the morrow. So saying, he stretched himself on the ground under a tree, and was soon fast asleep, snoring loudly.

Thor thought the giant's advice good, and attempted to open the wallet, but to his surprise found that he could not loosen the strings. He drew in his belt and attempted to break them, but failed in this also. Then anger filled his heart, and taking his hammer in his hand he went to where the giant lay sleeping and launched the hammer full in Skrymir's face.

The giant stirred, half awoke, passed his hand over his face, and fell asleep again. Thor, chagrined by his failure, withdrew; but he could not sleep. Hunger kept his anger alive, and toward midnight he drew in his belt, and going again to the giant threw the hammer with such force that the head penetrated the giant's skull.

Skrymir stirred, opened his eyes, passed his hand over his head, and said: "Did a leaf fall from the tree? Ah, Thor, you are up late! You should get some rest before our long journey tomorrow." And he fell asleep again.

Thor, more chagrined than before, again withdrew; but he could not sleep, and when the first flush of dawn was in the sky he went again to the giant, drew in his belt to the last hole, and threw the hammer with such force that it sank, head, handle and all, into the giant's brain.

The giant woke, sat up, passed his hand across his forehead and said:

"I am sure an acorn must have fallen on me to wake me up like this! But it is no matter; it is day, and we will make an early start. Come, let us go!" And he started off at a great pace.

Thor, angered and disgusted, followed him. In a few hours they reached the end of the forest, and the giant said to Thor:

"You are now in giant-land. The road to Utgard Castle lies that way; my path lies in the opposite direction, across those mountains. But once again let me persuade you not to make this journey you have in mind. Nothing but harm can come of it."

But Thor shook his head, and started off along the road indicated by the giant, while the latter, taking great strides in the opposite direction, was soon lost to sight.

Thor found it a three days' journey to Castle Utgard. The castle stood in the midst of a great plain, surrounded by ice and snow. The castle was so high that Thor had to bend his head all the way back to see its top. Its great gates were guarded by two giants, bearing sword, spear and shield. The doors not being opened promptly enough to suit Thor, he threw his hammer against them. The lock shattered, and the doors swung inward.

Thor entered a great gloomy hall, with rows of giants ranged around its walls. At the farther end of the hall sat the giant king, Utgardeloki, on a high throne. Thor advanced toward him.

The giant king recognized Thor, and spoke first, saying:

"I know you, Thor, by your hammer and by the belt you wear. It is long since one of your race has paid us the

honor of a visit. We are appreciative of the honor you show us by coming here, and we will do our best to entertain you. We will show you feats of strength, and we hope that you will give us some evidence of that prowess with which rumor credits you."

Thor was not averse to this, but said that he was thirsty after his long journey.

"Ah," said the giant king. "Are you a good performer at the mead horn?"

"Yes," said Thor, proudly. "I have never seen a horn of mead so deep that I could not empty it at a single draught."

The giant spoke to his attendants, who presently brought into the hall a drinking horn so long that its little end remained outside the door. Thor looked at its size with some misgivings, but being very thirsty, he put his lips to it and took a deep draught. But when he had finished he found to his disgust that the level of the liquid was not appreciably altered.

The giants looked amused, and Thor, somewhat nettled, took a deep breath and applying his lips again to the drinking horn drank until the veins stood out on his forehead; but when he had finished he found that the liquid had been lowered just enough so that the horn might be carried without spilling.

Utgardeloki laughed, and the other giants echoed his merriment. Then the giant king said:

"Now that you have quenched your thirst, we have a game here for children. It is to lift my cat from the floor. I would not have mentioned it had I not found you so unexpectedly weak."

There came into the hall a strange looking cat, with scales instead of fur, and with eyes that shone fire. Thor placed one hand under the animal and attempted to lift it, but the cat only arched its back more and more, until when Thor had reached as high as he could he had succeeded in lifting but one foot from the floor. Disgusted and angry with himself, he gave over the attempt.

The giant king laughed long and loudly, and the other giants joined in his laughter. Fierce anger seized Thor's heart, and he clenched his fists until the knuckles grew white, and, shaking his hammer at Utgardeloki, dared him to single combat. But the giant king said:

"All that has been has been in sport. I see no reason for anger. Still, if you insist, I will have my old nurse, Elle, wrestle a fall with you."

A toothless old woman came into the hall and springing at Thor seized him around the waist. The god struggled mightily, and withstood her long, but eventually he was forced down on one knee. At this Utgardeloki stopped the sports, saying that it was now time for the feast. But Thor was too chagrined and disgusted to eat or drink much, and all thoughts of warfare had gone from his mind.

In the morning the giant king accompanied Thor outside of the castle to show him the road back to Asgard, and when the gates were shut after them he said:

"Now that you are out of my domain, and shall never enter it again, if I can help it, I will open your eyes. All that you have seen has been enchantment, as it were a strange dream. I am Skrymir, who met you in the forest. When I learned your errand my heart sank within me, for I knew of your prowess and of the enmity between your race and mine; and I endeavored to dissuade you from carrying out your purpose of coming hither. Failing in this, I had recourse to enchantment. By magic I tied the strings of the wallet; when you struck at me with your hammer I placed a mountain between us. Three deep glens have been made in it by the might of your arm. The drinking horn had its

little end in the ocean. On your way home, when you come to that arm of the sea across which you were forced to swim on your way hither, you will find it so lowered that you can wade across it knee deep. My cat was no cat, but the great world-serpent that lies coiled round the earth, holding the world together. When you put forth all your strength to lift him and, as you thought, failed, we saw that the serpent had great difficulty in holding on to his tail, and we feared lest he should be forced to let go. When you, as you thought, lifted but one foot from the floor, we felt the foundations of the universe tremble. Elle was old age, before whom all, even the gods, must bow. But come not again, Thor, for I fear you; and I have other enchantments that you know naught of, and long will I be able to withstand you."

At these words anger filled Thor's heart, and he threw his hammer at the speaker; but Utgardeloki and his castle had vanished, and there was naught to be seen but an empty plain.[2]

Waking time! Waking time! Lo, a man is born!
Born in Nature's wonderland, in life's fresh morn.
Nature's myriad wonders, beckoning, seem to say:
"Come, live with us and learn of us, in life's long day."

Working time! Working time! Life's high noon!
Waste no precious moment now, for night comes soon!
Much to learn, much to do, all that man can ask.
Summon every energy to life's great task.

Resting time—sleeping time! Lay the task away;
Thou hast earned a peaceful close of life's long day.
All thou hast accomplished, little may it seem;
May'st thou see it clearly after life's strange dream!

[2] The story of Thor and the giants is found in several places. The source to which the writer is chiefly indebted is the issue of *St. Nicholas* for October, 1880.

SCIENCE IN JAPAN

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THE Science Congress held at Tokyo from October 30 to November 11, 1926, under the auspices of the National Research Council, gave to "overseas" delegates a favorable opportunity for the study of the scope, organization and personnel of Japanese science. Most delegates were pleasantly surprised at the nation-wide enthusiasm for scientific investigation and especially at the remarkable progress made during recent years. As recorded in "Scientific Japan Past and Present," the entire history of organized scientific research in Japan covers little more than a half century—a striking contrast to history of scientific study in other Pacific countries. In the United States before 1875 more than two hundred learned societies, national and state surveys and laboratories had begun publication of transactions. Several American societies have celebrated their hundredth anniversary and two their hundred and fiftieth anniversary. In Mexico the National Museum was founded in 1825 and the Geographical Society in 1833. The learned societies in Colombia, Peru, Bolivia and Chile are even older. In New Zealand eight learned societies were holding meetings before 1870—including the Dominion Museum (1863) and New Zealand Institute (1867). In Australia the Royal Society was established in 1821, the Australian Museum in 1836, and before 1860 the Commonwealth had a rather full complement of universities, museums, surveys, observatories, botanical gardens and scientific societies. In Java scientific societies were holding meetings before the close of the eighteenth century, and systematic investigations of the Pacific Ocean took a prominent place in the programs of Russian scientific societies during the early part of the nineteenth century.

For Japan, the history of organized scientific research begins in 1871, in which year the Hydrographic Bureau was organized. This was followed in 1874 by the establishment of the Imperial Hygienic Laboratory at Tokyo and in 1875 by the Imperial Hygienic Laboratory at Osaka and the Central Meteorological Observatory. These four institutions constituted the governmental scientific equipment in 1875. Up to this time there are no national, prefectural or municipal scientific societies and no private scientific institutions of record. During the fifteen-year period—from 1875 to 1890—three government bureaus—land surveys, forestry experiment station and geological survey—were established, and sixteen scientific societies came into being: four medical, three engineering, one each for zoology, chemistry, mathematics, geography, meteorology, botany, anthropology, textile research, architecture and agriculture. For the decade from 1890 to 1900, six government bureaus (national and prefectural) and eleven scientific societies were formed; from 1900 to 1910, fifteen government bureaus and seventeen societies; since 1920, sixteen government bureaus, twenty-six societies. Thus, of the eighty official scientific bureaus supported by the Imperial Government, prefectures and cities, fifty-four (about 67 per cent.) have been established during the past sixteen years. Of the ninety-three unofficial learned societies and institutions more than half have held

their first meetings since 1910 and more than one fourth during the past six years.

That this remarkable growth of institutions and professional societies represents a genuine increase in numbers of scientific workers and in specialization of interests is shown by the membership lists and the volume of publications. The enrollment in the more prominent professional societies in round numbers is: physics (three societies), 2,700; chemistry (three societies), 6,000; geography (three societies), 1,000; geology, 553; botany (two societies), 700; zoology (five societies), 1,200; forestry (two societies), 3,300; meteorology, 374; engineering (eleven societies), 18,000; medicine (thirty-five societies), 50,000.

A superficial comparison of lists of similar societies in other countries, taking into consideration population and stage of development of national resources, shows that in geography, geology, meteorology, ceramic chemistry, forestry, fisheries and systemic botany, the number of professionals is greater in Japan than that of most countries. In physics, chemistry and astronomy the numbers correspond to those of France, Austria and Italy, and stand below those for England, Germany and the United States. For botany other than systemic, the figures are approximately those of Holland, Scandinavia and Australia, and below those of the United States, England, Germany, Austria and France. For zoology the comparison is even less favorable and for anthropology the figures are about those for Belgium or New Zealand. There is no easily available method of comparison of numbers of research scientists in the membership of medical and engineering societies. The numbers in Japan compare favorably with those of most countries, except Germany and the United States, but doubtless in Japan, as certainly in the United States, most members of these professions are practitioners whose contributions to knowledge are incidental.

The history of Japanese higher education parallels that of scientific organizations. Systematic training of young men for professional and technical careers has been organized mainly during the past half century. This late development is surprisingly unlike that of other countries immediately bordering the Pacific. The Universities of Mexico, Lima and Cuzco were founded in the sixteenth century, San Tomas (Philippines) in 1611, and Santiago (Chile) in 1743. The charter of the University of Sydney is dated 1850, Melbourne 1853, New Zealand 1870. In the United States before 1875, 354 colleges and universities were teaching some kind of science and many of them were recognized centers of research. In Japan, previous to 1875, Keio, with its small medical school, and Dashisha University, without scientific departments, both established chiefly as missionary enterprises, were the only institutions listed as of collegiate grade.

In 1877 the Imperial University of Tokyo was founded for the training of men who desired to prepare themselves for professional and technical service. Its primary purpose was to bring together, enlarge and furnish more favorable opportunities for the scattered groups of writers, experimenters and observers who had been encouraged by the Tokugawa Shogunate to pursue scholarly careers. The university was given its present form—part American, part European, part Japanese—in 1886. The place the university was intended to take in the educational system is shown by the original list of departments: law, medicine, engineering, literature, science. Agriculture was included in 1890, economics not until 1919. At the present time the largest professional faculty is engineering, followed in turn by agriculture, science, literature, medicine, law and economics. The students number

about 5,000. The university maintains nine serial publications and seven research institutes outside the university campus.

Of the other Imperial universities Kyoto was founded in 1897, Tahoku in 1907 and Kyushu in 1910. Hokkaido, organized as an agricultural college in 1876 under the guidance of a group of men, was created a university in 1918. Fourteen medical and technical colleges apart from the universities were established between 1919 and 1926.

As bearing on the effect of Japanese university education on the development of science, it is worthy of note that the average age of students entering the science courses is 22.2, in the agriculture courses 23.2. Another feature of interest is that about 30 per cent. of the graduates are in teaching and scientific pursuits and but 20 per cent. in all lines of business, finance and commerce.

The history of civilization shows that science is a slow-growing plant in any soil and it is difficult to think its growth in Japan has been witnessed by men now living. Japanese scientific research and education give an impression of age. It seems highly improbable that the rapid recent increase in numbers of institutions, societies and workers represents an entirely new interest in the possession and utilization of scientific knowledge and a study of records and publications reveals a vista of scientific activity extending far into the poorly recorded past. Some branches of scientific knowledge were widespread and familiar to all classes long before contact with the outside world brought new methods and new ideas; other branches were part of the knowledge of scholarly men only; still others seem to have been outside the experience of the Japanese people.

Botany in Japan has enlisted the interest of many able minds since the eighth century. Up to the seventeenth century attention was given almost wholly to the search for, testing and methods of use of plants for medicine and for food. From the seventeenth century to the Restoration (1868) an amazing amount of descriptive work was done—the differences and relationships of plants as based on structure, type of flower, kind of fruit and habits of growth were worked out.

Between the years 285, when the first Korean professional student of medicinal plants was united to the Imperial Japanese Court, and 900, the knowledge of plants possessed by the Chinese seems to have been fairly well absorbed. In 929 this information was embodied in a twenty-volume text-book, prepared by Shitago. In 1156 three books—drug plants, perfumery plants and cereals—were written by Seiken. In the middle of the sixteenth century some knowledge of foreign medicinal plants was obtained from Portuguese and Spanish visitors and then the door was closed and the Japanese continued without outside help to gain a knowledge of their flora. In 1696 Jyaksui published a treatise descriptive of 189 food plants and started on the remarkable one thousand-volume encyclopedia of natural products of Japan. After writing 362 volumes the author died, but his pupils continued the work and in 1735 the last of the remaining 638 volumes were issued. Before his death in 1714 Kaibara Ekiken had written a treatise on the natural history of Japan, in which 358 plants are described as indigenous and twenty-nine as imported. Ranzan's work on mountain flora of Japan—herbs, two volumes; trees, four volumes—was written in 1765 (translated into French 1873). Ino Jyaksui published monographs on orchids, fungi, bamboos and cherries. Rausui, who died in 1776, published an eighteen-volume work on the botany of Loo Choo Islands. Between 1720 and 1752 a natural history survey under the direction of four distinguished botanists

was conducted by the government and local centers of study were established by imperial decree. In 1782 a natural products bureau was established at Kagoshima. Among many works published during the twenty years following is an illustrated agricultural botany in twenty volumes. Similar bureaus were established at other places. From the one at Mito came the San Kai Sho Hin (products of mountains and seas) in one hundred volumes. As an aid in exchanging information the workers at these bureaus held annual exhibitions, beginning in 1757 and continuing without interruption until 1827. In a modified form these exhibits continue to the present day. The Tokugawa Shogunate, which did little for learning in general, liberally supported botanical studies, and the present Marquis Tokugawa, himself a student of botany, established and endowed in 1898 the Tokugawa Institute for fundamental research in plant science. Though expressed in different terms, the Japanese long ago recorded relations in the plant kingdom which modern scientists express by the terms Order, Family, Genus, Species. So that when the Dutch botanist Thunberg visited Japan in 1776 and called attention to the effective simplicity of the Linnean system of nomenclature, all the Japanese students of plants had to do was to change their cumbersome descriptive phrases into the shorter and more precise Latin terms. At the time when modern American and European methods of botanical research were eagerly adopted by the Japanese, the systematic botany of Japan was probably as well known as that of any other region. With this much already accomplished, the ground was prepared for investigation in cytology, pathology, micro-anatomy, physiology and genetics of plants. The background of widespread knowledge and interest in plants, added to the voluminous descriptive records, doubtless accounts in large part for the present high rank of botany in Japan.

Horticulture

For more than a thousand years the Japanese have been not only students of plants but also lovers of plants. Their remarkable achievements in floriculture, horticulture and forestry are too well known to justify extended comment.

In 1681 Moto Katsu described the culture methods of 117 herbaceous flowering plants and in 1795 printed a twenty-volume work on camellias, azaleas and chrysanthemums which remains a standard treatise. In 1698 to 1699 Kaibara described culture methods for 190 species of flowering plants and illustrated 110 species of flowers. Other important works appeared in 1713, 1715, 1717, 1735. A five-volume work on rhododendron appeared in 1733. No less than fifty descriptive illustrated books on the morning-glory and thirty on Ardesia appeared between 1795 and 1818.

Systematic study of food plants is represented by hundreds of volumes bearing dates previous to 1800, and the study has been vigorously prosecuted down to the present time. Three purposes seem to underlie these investigations of food plants; introduction of new species, improvement in cultivation of known species and full knowledge of edible wild plants which might be used in time of crop failure and scarcity. Many of the treatises are in three to ten volumes. Tsunemasa's great work on the flora of Japan (1828) is in ninety-three volumes and Yakusa's masterpiece on useful plants (1856) treats of 1,201 species, besides six hundred species of trees still in manuscript.

Comparison of Japanese plants with those of other regions dates largely from 1776, the date of the visit of the Dutch botanist, Thunberg. By 1856 the plants of Japan had been listed on the Linnean system and equivalent European and

Asiatic species had been recognized. In 1857 a bureau for the study of non-Japanese plants was established at Yedo and in 1877 Riokichi, who had studied in America at Cornell, became professor of botany in the Tokyo Imperial University. His students include most of the Japanese botanists of the present century.

Forestry, like other branches of plant science, has been practiced in Japan unofficially for many centuries. The necessity of replanting, methods of replanting and the relation of forests to agriculture are the subjects of many books and of chapters in treatises on botany. In a publication dating from 1732, forests are given equal rank with cultivated crops and fish as natural resources to be studied and regulated.

Medicine

When the present enviable position of Japan in medical research is considered it is interesting to note that definite knowledge of the make-up and functions of the human body first came to the Japanese in 1771. Before that time theoretic medicine followed the Chinese system of "essences," "influences," "external causes" and "internal causes," supplemented by a comprehensive knowledge of healing herbs. Two important features of this early period were the teaching of Nagata about 1200 A. D. that "the secret of curing lay in helping natural agencies in their work of healing" and the introduction of crude Portuguese surgery (1568), which grew into a school called "Surgery of Southern Foreigners." As at other stages in medical practice, the physicians separated into warring schools, "Classical Medicine" and "New Medicine."

Early in 1771 Sugita happened to see an illustrated Dutch anatomical work and Mayeno saw another in a ship captain's library. Neither of these men could read Dutch, but they saw the illustration of the internal organs of the human body and were surprised to find that these organs were entirely different from those described by Chinese physicians. At first thought the discrepancy seemed natural, for externally foreigners were different: they have white skins and red hair; they sit on chairs because their knees don't bend; they use artificial heels because they have no heels of their own. But these explanations did not satisfy. The two students wanted to see for themselves the inside of a Japanese. But dissection was not only prohibited by law but was regarded with horror. Fortunately for Japanese medicine, the body of an executed criminal was made available by surreptitious means. Dissection showed that Japanese bodies and Dutch bodies were constructed alike. The date of this astounding discovery, March 4, 1771, is one of the most memorable in the history of Japan. The value of western knowledge was established and the Dutch became the scientific leaders. In 1784 Toyo dissected more criminals and wrote the first Japanese book on anatomy, "Records of Viscera." European physiology was introduced in 1836 and from that time on medical literature in all languages was imparted and physicians from Holland, France, Germany and England were invited to make official visits and to teach.

Mathematics

Mathematics of early Japan was the mathematics of the Chinese. The Chinese numeral system, the calendar, the multiplication table and calculating machines, and what stood for algebra and geometry were Chinese affairs which reached their highest stage of development in the eighth century. In Japan it was considered as a game to be played by a few unpractical priests and recluses. Japanese mathematics rose in the seventeenth century as an adjunct to land surveying. From it grew an indepen-

dent system of written algebra, the solution of equations and the treatment of circles. Seki's "Principle of the Circle" is held by some historians as a discovery equal in merit with the invention of Infinitesimal Calculus by Newton and Leibnitz. The astronomical observatory established at Kanda in 1744 yielded material for important contributions to celestial mechanics. From the seventeenth century on the Japanese mathematicians appear to have mingled their science with that from Europe in proportions and values impossible to differentiate.

The facts, principles and methods pertaining to physics, chemistry and to a large degree seismology and volcanology seem not to have been indigenous in Japan. They were bodily grafted onto ideas obtained from the Portuguese, the Dutch, and, after 1868, from the entire world.

Considered as a whole, I hazard the guess that judging from numbers engaged in scientific pursuits and the enthusiastic interest displayed, Japan as a scientific nation ranks next to the United States, England and Germany; something above any other European country and far above Australia, New Zealand, Canada and all South American countries.

And as Japan has energetically played the modern scientific game only during the present generation and many of her outstanding men have, therefore, not reached their prime, and as the crop of enthusiastic youngsters now in training is relatively large, another generation may witness even more favorable ranking.

It has interested me to record certain superficial observations regarding the conditions surrounding scientific research and scientific education in Japan.

Scientific institutions, professional societies, universities and technical schools appear to have been founded in response to demonstrated needs and only after adequate financial support and satisfactory personnel is assured. The scope of the institutions is clearly defined: there is little undesirable duplication and overlap. To a degree unknown in most countries, scientific institutions in Japan are financed by pooling contributions from the Imperial Government, from prefectures, from cities and from individuals.

As compared with the United States at least, Japanese professors and scientists are more highly respected and are given better opportunities. Provision for travel and study abroad is common. Japanese scientists are proud of their teachers, honor them; but they also follow their method to an undesirable degree.

Science appears as required study in nearly all educational institutions. Even in the elementary schools, science is taught by men who make much use of direct out-of-door study.

Enthusiasm for study of animals seems much less in evidence than for study of plants and of physical material, and there is a surprising lack of interest in the study of the human race except as history and the development of art. Most of the men who rank as anthropologists are professors of medicine, who treat race problems more or less incidentally.

The botanical gardens of Japan rank with the best. They are many, well planned, well kept, and serve as valuable adjuncts to teaching and research. The zoological gardens and aquaria are interesting but have much less scientific value; they are below American standards. The art museums and historical museums are admirable. They house and display treasures of surpassing interest and value. The natural history museums are few in number and contain little of distinction. Most of them are

miscellaneous collections similar to those used to illustrate lectures in the smaller American colleges.

Japanese science is fortunate in never having to meet the opposition of a religious system. The prevailing religions encourage the search of knowledge in any form, in any direction, to any extent, and Confucius taught that the pursuit of knowledge is the highest expression of human endeavor. I have gained the impression that Christianity would stand higher in the estimation of many educated Japanese if its record for stifling scientific research could be wiped out.

Japanese science, like that among other progressive people of modern times, is partly the result of original thinking but largely the result of developing and adapting knowledge obtained elsewhere. In some branches of science there appears a tendency to accept the leadership of foreign teachers without critical investigation, thus repeating the experience of America with reference to German science during the last quarter of the nineteenth century. Japanese science is "borrowed" in the sense that American science was "borrowed" from Northern Europe and that in turn from Greece and Arabia.

The guiding principle is that expressed by the far-sighted Emperor Meiji: "Knowledge shall be sought for far and wide."

FIG. 1. RESTORATION OF THE DEVONIAN FOSSIL FORESTS FOUND AT GILBOA, N. Y.

IN THE FOREGROUND IS SEEN AN IDEALIZED REPRODUCTION OF THE ROCK SECTION AT GILBOA, SHOWING THE THREE LEVELS AT WHICH FOSSIL STUMPS WERE FOUND. THE BACKGROUND IS A PAINTING OF THE FOREST AS IT PROBABLY LOOKED WHEN LIVING, WITH LIFE-SIZE RESTORATIONS AT EITHER SIDE. THIS RESTORATION IS AN EXHIBIT IN THE NEW YORK STATE MUSEUM, HALL OF FOSSIL PLANTS. IT WAS EXECUTED BY THE ARTIST AND

THE OLDEST KNOWN PETRIFIED FOREST

By WINIFRED GOLDRING

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DREAMS do come true, sometimes; and one of the most recent dreams of the New York State Museum was realized when on February 12, 1925, there was formally opened to the public the restoration (see Fig. 1) of the extensive forests that flourished in eastern New York a few hundred million years ago during Upper Devonian (Ithaca) times. The history of the discovery of these trees and the gradual accumulation of material which led to the final solution of their nature is almost as interesting as the ancient trees themselves.

1. HISTORY OF DISCOVERIES

Back in '69, over half a century ago, the little village of Gilboa in the Catskills (Schoharie County) came suddenly into prominence from a paleobotanical point of view. In the autumn of that year the upper valley of the Schoharie Creek was swept by a great freshet which tore out bridges, culverts and roadbeds around the little village of Gilboa. But science, at least, has much for which to be grateful, for at the same time that all this disaster was caused the freshet very obligingly exposed in the bed rock along the creek standing stumps of fossil trees, all at the same level. The discovery of these trees was described in the Albany *Argus* of January 30, 1870, and in the twenty-fourth Museum Report (1872, for 1870); and it was considered of so much importance that it was brought by Professor Hall to the attention of the British Association for the Advancement of Science in 1872. Excavations were made during the year 1870 in the bed of sandstone containing these trees and five stumps and a number of fragments were taken out of this ancient forest. The greater part of this material was brought to the State Museum, where it has for some time constituted a remarkable exhibit of the ancient, extinct flora of the state.

The Gilboa collections were submitted for examination to Sir William Dawson, of Montreal, then principal of McGill College, and in his day an authority on the plants of the Devonian. Dawson placed these trees in a genus of true ferns, represented by trees, and distinguished two species, *Psaronius textilis* and *P. erianus*. The genus has in these later years been thoroughly studied; and it has been found that the structure is quite different from that of the Gilboa trees. Moreover, Psaronius belongs to the Carboniferous, the period of our coal trees, and is much more recent by millions of years than these Upper Devonian trees. The problem of the nature and relationship of our Gilboa trees was still left to science, and seemed incapable of solution until the summer of 1920.

It had always been assumed that our Devonian trees had a scattered distribution—no one dreamed of a vast and extensive forest. The old locality had long since been covered up and the rocks at the level in which the trees were discovered did not outcrop again in this area. Nothing more was heard of these fossil stumps until in 1897, when Professor C. S. Prosser, then connected with the New York State Survey, reported finding some small specimens, from a higher horizon, lying loose at Manorkill Falls about a mile above Gilboa. Occasional attempts since then to relocate this primeval forest of the Devonian period

FIG. 2. RESTORATION OF THE DEVONIAN SEED-FERN TREE

SHOWING THE BULBOUS BASE, THE GRADUALLY TAPERING TRUNK AND THE CROWN OF LARGE FRONDS BEARING AT THE TIP, IN SOME CASES, THE SEEDS AND SPORE-BEARING ORGANS. RESTORATION BY MISS WINIFRED GOLDRING.

were fruitless until the summer of 1920, when special effort was made to add to the collection of Devonian plant material already in the hands of the museum. In this year the efforts to relocate the Schoharie forest or to find some additional evidence as to its extent led to the discovery of upright tree stumps not in the original locality but 6,400 feet south, at the higher level along the road in the vicinity of the lower falls of the Manorkill, tributary to the Schoharie Creek (see Fig. 6). Five specimens were taken from this site. These trees, as was the case with those first discovered, were found with their bases resting in a bed of shale, black or greenish-black in color, and representing the original mud in which the trees grew. This tree locality, which constitutes the highest horizon in which these stumps have been found, has an elevation of 1,120 feet above tide, and when the Gilboa reservoir is filled the flow line will be some feet above this spot. The old locality, on the same side of the Schoharie just above the old Gilboa bridge, had an elevation of 1,020 feet A. T., giving a difference of just one hundred feet between these two tree horizons. Since 1920 the city of New York has been doing construction work at Gilboa, preparatory to impounding the waters of the Schoharie Creek for the future use of its citizens. The resultant reservoir will extend over a length of nearly seven miles and will drown the village of Gilboa and its vicinity, including the two above-mentioned fossil tree localities. In 1921, in the course of quarrying in connection with the work on the dam, the old locality, which is directly at the spot where the dam was being built, was uncovered and seven stumps were found, some of them too badly broken to permit removal. One specimen taken weighs nearly a ton and has a circumference of nearly twelve feet (diameter about four feet). In a quarry about half a mile (2,300 feet) down stream from the old locality, trees were found at a level of 960 feet above tide, 60 feet below the oldest or middle locality, 160 feet below the highest level where trees were found. This quarry, known as "Riverside Quarry" (see Figs. 4, 5), has yielded the greatest number and also, on the whole, the largest stumps found. During one period, eighteen specimens were taken from an area fifty feet square, not counting those destroyed in quarrying. One of the largest specimens of this group has a circumference at the base of approximately eleven feet (diameter approximately 3.5 feet), a height of twenty-two inches and a diameter at that height of twenty-one and a half inches; stumps of greater height, but of smaller girth, have been obtained. At all the three tree horizons the stumps were found with their bases resting in and upon shale and in every case in an upright position with the trunk extending into the coarse sandstone above. The shale beds representing the muds in which the trees stood vary in thickness from six inches to two feet, more often thin than thick.

By the spring of 1924 with the additions to our collection, which we owe to the courtesy of the commissioners of the New York Board of Water Supply and the various engineers connected with the work, we had in our museum a total of nearly forty stumps, partial or complete, and a number of broken pieces. We have not added to our number of fossil trees since then; but they have been distributed among various museums and some even have gone into private hands. Taking into consideration with all these, those still at the quarry, the weathered stumps discarded, and those destroyed in quarrying, the number of stumps taken from these primeval forests must run into the hundreds, and continued quarrying will bring more to light. "Riverside Quarry" is not included in the area covered by the Gilboa reservoir, but its

FIG. 3. THE LOWEST FALLS OF THE MANORKILL, GILBOA, N. Y.
THE HORIZON WHERE THE SEEDS AND SPORE-BEARING ORGANS WERE FOUND IS AT THE LEVEL MARKED WITH A CROSS; THE AREA WORKED EXTENDED SOME DISTANCE TO THE RIGHT.

value as a fossil tree locality will be greatly lessened with the cessation of quarrying operations. Now that the rock layers containing the stumps have been located, it is quite possible that they can be traced around the hills and found outcropping elsewhere. In the area known, the tree localities have been found stretching over a distance of something more than a mile and two thirds. No forest as old and as extensive as this has anywhere been reported up to date. We therefore have in eastern New York, up to date, the oldest known forest in the world, and in our museum a unique and unmatchable exhibit.

Except for the discovery of the seeds, which was quite accidental as many very important discoveries are, we would still have been left with a forest of fossil stumps and have been little better off than were Professors Hall and Dawson in 1869. By the merest chance, Dr. Rudolf Ruedemann, state paleontologist, who was on the ground with some other collectors in the summer of 1920, came across a slab of dark shale containing seeds along the edge of the Schoharie Creek in the vicinity of the Manorkill Falls (see Fig. 3). The slab was traced to the bed of shale from which it was derived and a number of good specimens were obtained. Later in that summer the writer and an assistant worked this bed of shale and a fairly large collection of excellent material was obtained, including not only the seeds, but another kind of fruiting body, bits of foliage and roots. Further efforts in the summer of 1923 led to the discovery of a new locality about thirty feet south of the original exposure, and in this and the following year our already unique collection was considerably augmented in both quantity and quality. Collecting in the spring of 1925 showed both localities to be practically exhausted, and besides this whole area will eventually be under the deep waters of the Gilboa reservoir.

In addition to stumps, portions of the trunks of these fossil trees were found in 1920 and later. In the early summer of 1923 bases of stumps were found in "Riverside Quarry" with the long, radiating strap-like roots attached, so that there could no longer be any doubt that these trees grew *in situ*. In 1925 three specimens of the outer bark showing petiolar scars were brought in by Mr. R. Veenfliet, Jr., a local collector. The greatest numbers of the trees comprising these ancient forests were of this "Gilboa" tree type, but evidences of two other kinds of trees have been found. One is a Protolepidodendron, a lycopod-like tree, similar to the Naples tree, Protolepidodendron primaevum (Rogers), known for so many years from the Portage beds of central New York. This tree has not yet been described. In the fall of 1925 two specimens of another type of tree with long, grass-like leaves on the trunk were collected in "Riverside Quarry," and they have been described under the name Sigillaria ? gilboensis (N. Y. State Museum Bull. 267, 1926) as another lycopod type of tree.

In the early summer of that year a rootstock was found in the same quarry, which may belong to either of the last two mentioned types of trees.

2. Upper Devonian Geography and Present Geology

The Gilboa trees afford an index to the geography of the western Catskills and the Schoharie valley during the late Devonian period to which they belong. During these times, the present Catskill

FIG. 4. RIVERSIDE QUARRY, GILBOA, N. Y.

THIS QUARRY IS LOCATED ALONG THE SCHOHARIE CREEK, ONE HALF MILE BELOW THE DAM. FROM THIS QUARRY WAS TAKEN THE STONE USED IN THE DAM AND THE GREATEST NUMBER, AND THE FINEST, OF THE FOSSIL TREE STUMPS. THIS CONSTITUTES THE LOWEST TREE HORIZON AT 960 FEET ABOVE TIDE.

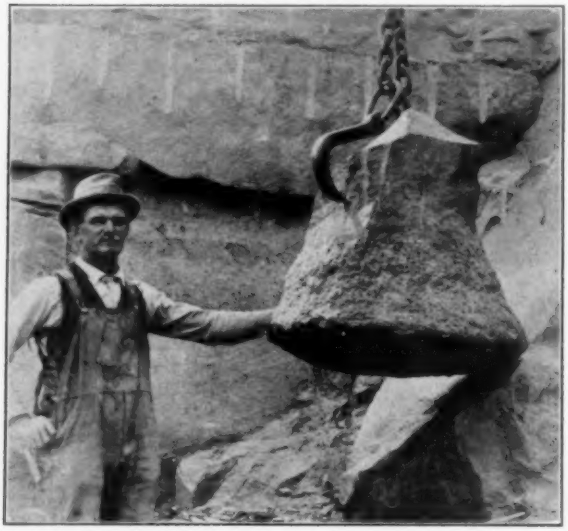

FIG. 5. FOSSIL TREE STUMP IN RIVERSIDE QUARRY

BEING REMOVED FROM THE SPOT WHERE IT HAD RESTED FOR MILLIONS OF YEARS.

FIG. 6. FOSSIL TREE STUMP

IN PLACE AT THE HIGHEST TREE HORIZON AT 1,120 FEET ABOVE TIDE, ALONG THE ROAD ABOVE THE LOWEST FALLS OF THE MANORKILL. THE MIDDLE HORIZON (1,020 FEET ABOVE TIDE) IS AT THE SITE OF THE GILBOA DAM.

Mountains formed the low shore-line of a shallow sea; and the continental land lay off to the east of the Catskills, extending far into the present area of the Atlantic. This shallow sea covered the interior of the state and country and received the heavy drainage from this eastern land mass. The southwesterly flowing rivers brought down débris of the primitive vegetation with which that lost land was wooded, and scattered the remains, leaves, stems, branches, etc., through the vast delta and shore deposits. Perhaps nowhere else in the known records of the rocks is there such an extraordinary accumulation of the land flora of this geological age as in these sands which underlie the slopes of the Catskills westward into the Alleghany plateau. Plant remains were mingled with the earliest of the fresh water mussels which burrowed in the sands of the river mouths; at times the rivers carried the forest growth far out among the marine deposits and it was mingled with the animal remains of the salt sea. This close intermixture of terrestrial and marine conditions is most abundantly shown in the lower or earlier part of the Catskill terrane. The coasts of those days were very unstable, which would give a swampy shore-line. Forests of primitive trees grew along these shorelines, spreading down to the water's edge. Gradual submergence of the coast carried these trees beneath the water and the sediments piled up over their bases. At a later period when the sinking basin was again filled by deposits the forest again crept down to the water's edge. The discovery of these horizons of fossil tree stumps shows that three successive forests flourished here, were submerged, destroyed and buried. The fact that the stumps are buried in a fairly coarse sandstone indicates a rapid destruction and burial.

The geologic horizon of the occurrence of the Gilboa trees apparently is the Ithaca formation. The Oneonta is characterized by red beds and they are not found as low as any horizon containing tree stumps. Red beds characteristic of the Oneonta are seen a few feet above the highest tree horizon at the Manorkill. Collections made at a higher horizon four miles to the south at the intake of the tunnel show a prevailing Ithaca fauna; and it is therefore apparent that we have an intermingling of Ithaca and Oneonta sediments. The fresh-water unio, *Amnigenia catskillensis*, occurs in a massive sandstone one and a half miles northeast of Gilboa, some 600 feet above the level of the Schoharie Creek at Gilboa, which clearly indicates that the horizon of this shell is above that of the tree trunks found at Gilboa. The Ithaca fauna is also present on the hillsides above Gilboa; and all this indicates that we have in this area an interfingering of the Oneonta and Ithaca sediments.

3. Structure of Gilboa Trees

A full, technical description of the Gilboa trees may be found in a previous article by the writer (N. Y. State Mus. Bull. 251, 1924, pp. 50–93) by those who care to go into more detail than is given in the following description.

The stumps taken from the three horizons show great variability in size and some variability in shape (see Figs. 7, 8). The bases of the stumps are bulbous, as might be expected of certain trees growing under swampy conditions, and show a circumference at the base from three feet and less up to nearly twelve feet (diameter less than one foot to nearly four feet). In general, the height at which the trunks were broken off varies from a few inches over one foot to about three feet or slightly over, but in the spring of 1925 a large specimen was taken from "Riverside Quarry," which extended up into the trunk for five and a half feet. Some of the stumps narrow quite gradually from the

FIG. 7. FOSSIL STUMP OF THE *TEXTILIS* TYPE

SHOWING RAPID NARROWING ABOVE THE BASE AND THE NETWORK OF INTERLACING STRANDS OF STRENGTHENING TISSUE. HEIGHT ABOUT 3 FEET; CIRCUMFERENCE AT BASE 6 FEET 3 INCHES (DIAMETER 23.8 INCHES).

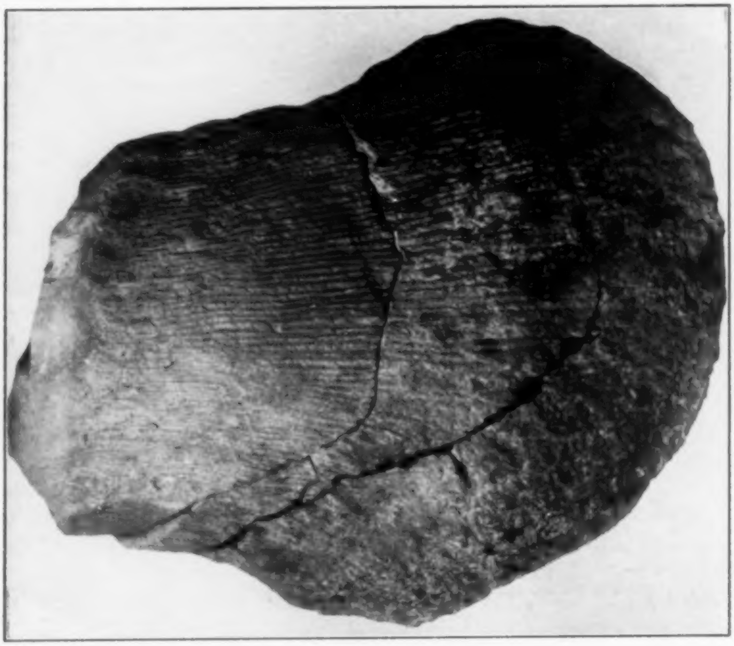

FIG. 8. FOSSIL STUMP OF THE *ERIANUS* TYPE

SHOWING THE MORE OR LESS PARALLEL STRANDS OF STRENGTHENING TISSUE. THE STUMP NARROWS GRADUALLY ABOVE THE BASE. HEIGHT 38 INCHES; GREATEST DIAMETER (LEFT TO RIGHT IN FIGURE) 38 INCHES; DIAMETER AT RIGHT ANGLES TO THIS 30 INCHES.

bulbous base into the trunk, others very abruptly. The parts of trunk above the heights shown in the stumps, which have been found infrequently, are in a flattened condition. The museum has two of these specimens, one over four feet long and the other over three feet long. In the case of the latter, which was taken from the underside of an overhanging ledge, as much again of the trunk had been broken away and lost; and, beyond the section obtained, the trunk continued into the solid rocks with little, if any, diminution in width. Another specimen, too poor to be removed from the rock, showed some twelve feet of slender trunk which must represent a portion near the top of a large trunk or the trunk of a very small tree. Judging from the stumps and the portions of trunks, the largest of these trees must have reached heights of thirty to forty feet.

The outer cortex is the only structure of the stumps and trunks of these trees that is to any extent preserved. The interior structures have been washed out and the cavity left filled with sand which has helped preserve the shape of the stumps in fossilization. The structure of the outer cortex is similar to that seen in a group of Carboniferous seed-ferns (Lyginopteris, Heterangium). It consists of interlacing strands of strengthening tissue (sclerenchyma), forming a network or more or less parallel (see Fig. 9). In transverse sections, unlike the Carboniferous forms, the sclerenchyma appears in the form of dots or short thick irregular lines, irregularly scattered. This zone of the outer cortex varies from an inch or less to several inches in thickness, depending upon the size of the stumps. In the majority of cases, the outside portion of the outer cortex is missing, but it is well shown in several cases. The outer surface is marked with shallow ridges and furrows, in some cases giving the effect of a bark; in other cases the outer surface is only irregularly furrowed and wrinkled or even just roughened, some of which is undoubtedly due to shrinkage in preservation; but in either case the outer surface appears to be composed of layers of sclerenchyma forming a kind of bark, which in the living tree probably had a covering of ramentum or fibers. The underside of the base of the stumps (see Fig. 10) is quite strikingly furrowed in a radiate manner, and in some specimens a depression is seen at the center. The base as well as the sides has the outer zone or covering of sclerenchyma layers above which is the zone several inches thick, varying according to the size of the stumps, of interlacing sclerenchyma strands.

The interior structure of the trunk for the present remains unknown. A transverse section of one of the smaller trunks shows toward the center an irregular, thin ring of sclerenchyma tissue and within this ring and to some extent outside are irregularly scattered strands of sclerenchyma tissue. The scattered sclerenchyma strands may be due entirely to some maceration before preservation; but the ring itself appears to be a definite zone, part of a missing central cylinder of strengthening tissue. Transverse sections of larger trunks were made, but nothing was found. Success in this line can probably only be attained when a petiole or rachis of a frond is found preserved in such a condition that thin sections can be made for study.

In the earlier collections specimens of roots were found, but no stumps were taken with roots attached. This brought forth criticism of our statement that the stumps were buried *in situ*. The discovery in the spring and early summer of 1923 of specimens showing the underside of the tree bases with roots attached (see Fig. 11) finally settled the question. The roots are long and strap-like and radiate from the margin of the base. One specimen was obtained under difficulties and set up in concrete to form a

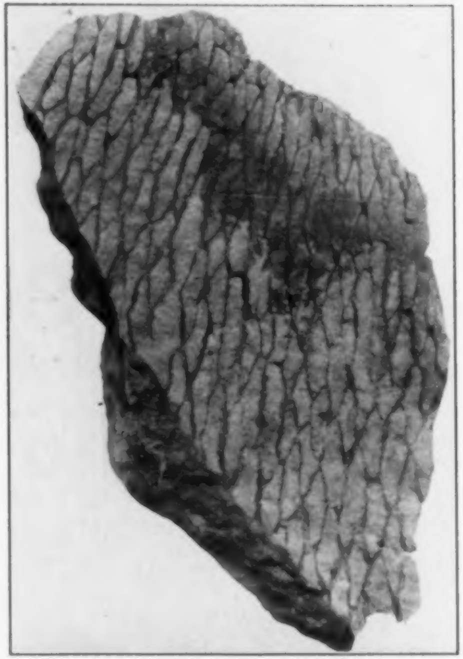

FIG. 9. PORTION OF OUTER CORTEX OF ONE OF THE STUMPS

SHOWING THE NETWORK OF INTERLACING STRANDS OF STRENGTHENING TISSUE, OF THE TEXTILIS TYPE OF STUMP. SLAB ABOUT 15 INCHES LONG.

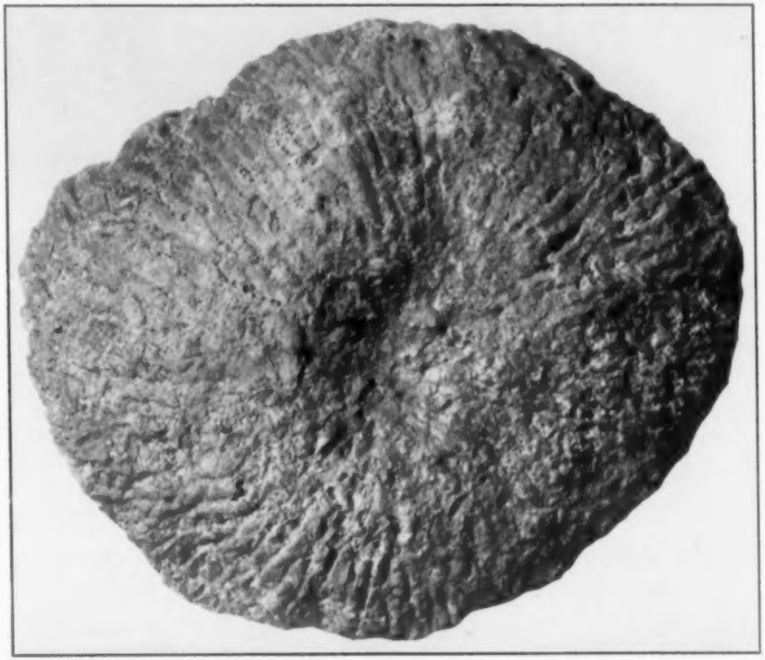

FIG. 10. UNDERSIDE OF BASE OF STUMP OF *TEXTILIS* TYPE

SHOWING RADIATING RIDGES AND FURROWS AND THE CENTRAL DEPRESSION. DIAMETER 25 INCHES.

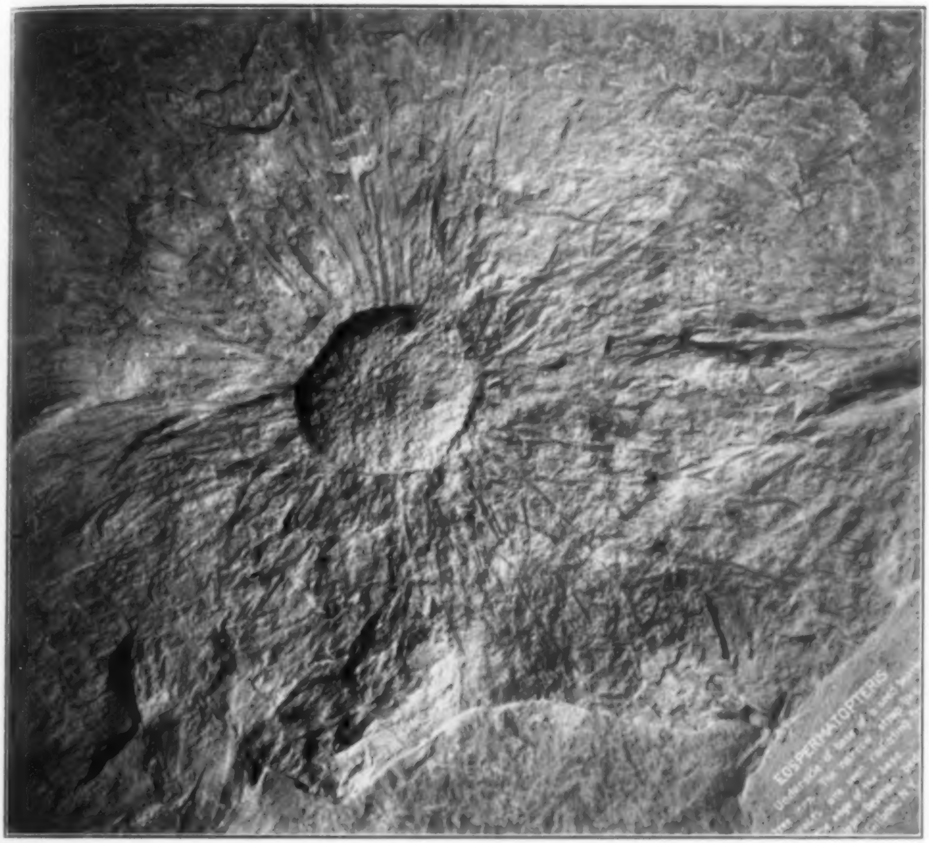

FIG. 11. UNDERSIDE OF BASE OF SMALL STUMP

SHOWING THE RADIATING STRAP-LIKE ROOTS. STUMP 14 INCHES IN DIAMETER. SLAB 6 FEET 4 INCHES BY 5 FEET 7 INCHES.

museum exhibit, through the kindness of Mr. Henri Marchand, who was then working on the Gilboa restoration. The slab, as exhibited, measures five feet seven inches by six feet four inches. The base of the stump is about fourteen inches in diameter, and the radiating roots, from one half inch or less in width to around an inch, extend without termination as far as the rock is preserved. From a study of this and other specimens it appears that the roots were undivided. Much larger specimens were found in the quarry with roots at least nine feet long, but it was impracticable to get them out. The museum specimen is in sandstone, seen from the under side; but other specimens were found on the dumps some time later, showing the impression of the root base in the shale bed beneath the sandstone, often with the radiating roots well shown. The shale bed, as pointed out previously, represents the muds in which the trees grew.

The fronds of the Gilboa tree are compound, tripinnate (three divisions), and judging from the fragments and larger specimens collected, were at least six to nine feet long (see Figs. 12, 13). The pinnules were bilobed, with the lobes slightly recurved. The impression

FIG. 12. PORTION OF A FROND

SHOWING ULTIMATE DIVISIONS WITH PINNULES. THE PINNULES OR LEAFLETS ARE SET RATHER FAR APART. THEY ARE BILOBED WITH THE LOBES SLIGHTLY RECURVED. NATURAL SIZE.

FIG. 13. PART OF MAIN STEM, OR RACHIS, AND LATERAL BRANCHES OF FROND

THE FRONDS HAD THREE DIVISIONS AND MUST HAVE BEEN 6 TO 9 FEET IN LENGTH. GREATEST WIDTH OF SLAB, 2 FEET.

of the main rachis or stem of the frond in the widest part varies from three eighths inch to five eighths inch in the larger specimens. Both the primary and secondary divisions are alternately arranged. The petioles are described as slender and much expanded at the base and spirally arranged in about five ranks. Specimens of outer bark showing petiolar scars were collected in the summer of 1925; but, as yet, the museum has not located any specimens of trunks showing the attachment of the petioles. About 1870 or 1871 a Mr. Lockwood, of Gilboa, found the upper part of one of these trunks, with its leaf scars preserved and petioles attached. The specimen was described by Sir William Dawson as probably the upper part of one or the other of his species of Psaronius found in the same bed.

The seeds of this Upper Devonian tree (see Fig. 14) bear a strong external resemblance to those of the Carboniferous seed fern, *Lyginopteris oldhamia*, and to other Lyginopterid seeds. They were borne in pairs at the end of forked branchlets and were probably borne near the tip of the frond. Sometimes the dichotomies are such a short distance apart as to bring, frequently two, sometimes three, pairs of seeds close together, giving a clustered effect to the seeds. The seed is broadly oval (measuring in the larger specimens 5.3 mm x 2.5 mm to 6.4 mm x 3.4 mm) and inclosed in an outer husk or cupule, which in some cases appears to be lobed. Separate nutlets were found. They occur in groups of small, rounded, thick bodies.

The second type of fruiting body found has been interpreted to be part of the male fructification, a sporangia-bearing organ (sporangiophore), though no separate sporangia have been found. These sporangia-bearing organs are modified pinnules; they are rounded-oval, saucer-shaped to funnel-shaped, and are borne on branching pedicels. It is believed that the sporangia were clustered and attached to the underside of the sporangiophore near the place of attachment of the pedicel and extending out toward the margin.

The two species described by Dawson were distinguished by the arrangement of the sclerenchyma strands of the outer cortex which he interpreted as aerial roots; and to-day the species can stand only on those characters upon which they were originally separated, since we have discovered nothing further to add. His "*Psaronius*" *textilis* (Fig. 7) is distinguished by a network of interlacing strands of sclerenchyma and "*Psaronius*" *erianus* (Fig. 8) by more or less parallel strands. Only one kind of foliage has been found; also only one type of seed and male fructification. It would appear then that only in the internal structure of the trunks could these two species of trees be distinguished while living; for if the two species differed in foliage and fructifications, with all the collections that have been made, some evidence of this would have come to light. There may, however, be another explanation of this. The fact that stumps of the *textilis* type have been found in numbers greatly in excess of those of the *erianus* type may account for the collection of only one kind of foliage and fructification, especially since the localities from which the collection of this material was made were few and of limited extent.

4. Description of Forests and Restoration

By June, 1922, after more than half a century since their first discovery, we were in a position to place our trees in their proper relationship and to attempt a restoration. These Gilboa trees in general appearance must have resembled the tree ferns of the tropics to-day, and also of the ancient Carboniferous and Upper Devonian times. The Gilboa

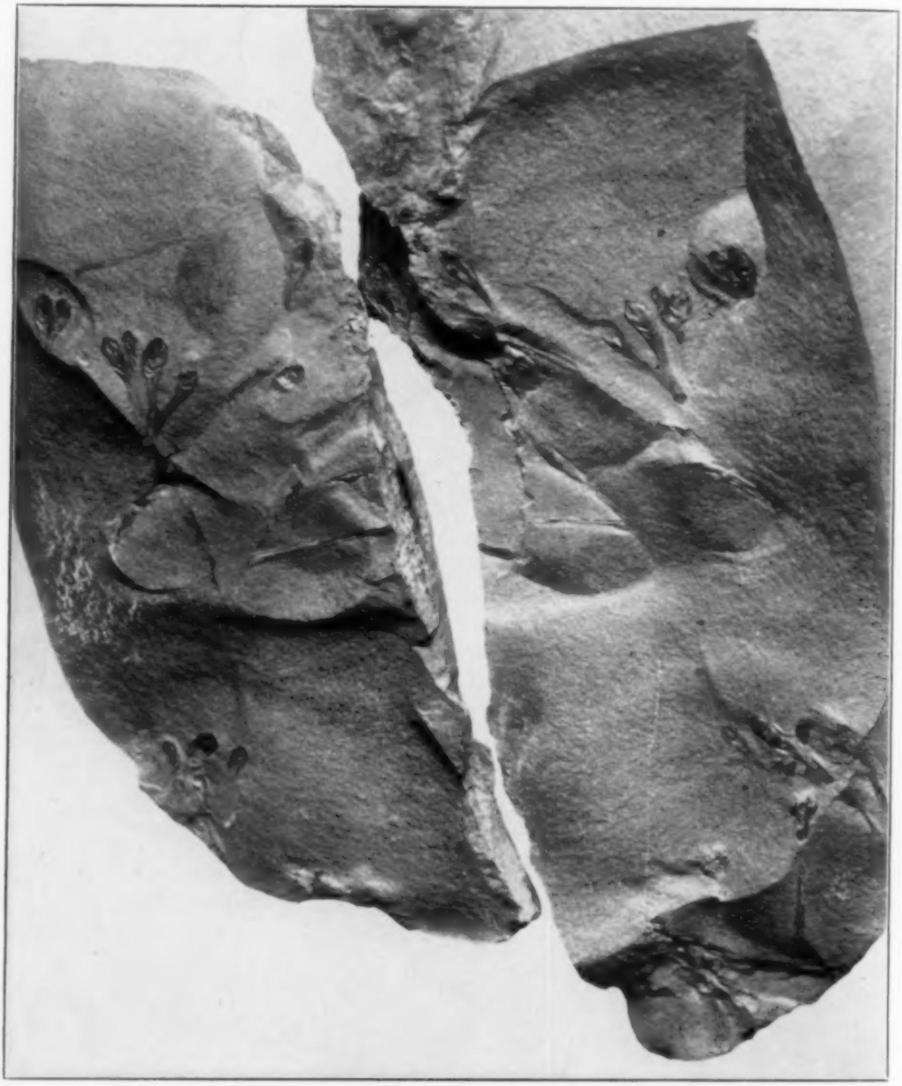

FIG. 14. SLAB SHOWING GROUPS OF SEEDS

THE SEEDS WERE BORNE IN PAIRS AT THE END OF FORKED BRANCHLETS AND WERE PROBABLY BORNE NEAR THE TIP OF THE FROND. NATURAL SIZE.

trees, however, do not belong in this group; they were higher types (seed ferns or Pteridospermophytes) standing in a position between the tree ferns and higher seed plants, and they differ from the true ferns in the possession of seeds and in the higher organization of the trunk. Since the name *Psaronius* had to be abandoned for these seed ferns, a new genus was created, *Eospermatopteris*, meaning "dawn of the seed fern" (from the Greek: eos—*dawn*; sperma—*seed*; pteris—*fern*), and the two species now stand as *Eospermatopteris textilis* (Dawson) and *E. erianus* (Dawson).

As already pointed out, these trees grew along a low swampy shore. They probably reared themselves to heights of at least twenty-five to forty feet and bore fronds at least six to nine feet in length, on the tips of some of which were borne the seeds. The bulbous base undoubtedly was buried in the swampy mud for some distance, as the roots are not heavy and the tree otherwise would not have adequate support. The foliage of the trees was not heavy, much looser than in the tree ferns of to-day and the pinnules or leaflets were far apart (see Fig. 2). There could have been no dense shade in this primitive forest; except perhaps for the heavy moist atmosphere sunlight could easily filter through. No higher forms of life existed there. The hum of insects was not heard, for there were no insects here at that time. All the sounds one would hear could one have been in that ancient forest would be the murmuring of the winds in the tree tops or sounds from the neighboring sea or at times the howling of destructive storms. Three such forests, undaunted, reared themselves in all their glory, were cut down by the sea, buried and fossilized.

The restoration of the Fossil Forests of Gilboa (see Fig. 1) was executed by the artist and sculptor, Mr. Henri Marchand, and his sons, Paul and Georges, under the supervision of the writer. As shown in the accompanying photographic reproduction, it includes an idealized reproduction of the Gilboa area, showing the three forest levels, and here the actual fossil stumps are used. In the center foreground flows the Schoharie Creek, which is joined at the left in a series of falls by a tributary, such as the Manorkill. Looking across and beyond this fossil section one sees the painting of our vision of this ancient forest as it might have looked in the height of its glory. The lycopod-like trees (*Protolepidodendron*), which grew in small numbers in these forests, are also shown in the painting. At both sides of the painting are life-size restorations of the Gilboa tree, which merge imperceptibly into the painting. The artist has depicted so understandingly and skilfully the character of the forest with its heavy moist atmosphere that this restoration is at the same time both a scientific reproduction and a beautiful piece of art.

REFLECTIONS ON CREDULITY

By Professor A. W. MEYER

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ALTHOUGH the rôle of scepticism looms large in the discussion of the intellectual development of man and the history of civilization, its twin sister, credulity, goes almost unnoticed. This fact probably can not be accounted for by saying that nobody knows what credulity is. We know no better what scepticism is, and there has been no end of discussion of consciousness, of mind, of life and of the soul. Yet who ventures to say what they are? Only the parvenu among modern physiologists, philosophers, or what not, attempts that. It is not my purpose to trace the history of credulity, to account for its changing prevalence, or to determine its rôle in civilization. That must wait for those fitted for the task. I merely wish to call attention to some matters of interest in connection with the question.

It seems that one may speak of waves of credulity and that these often have been associated with periods of emotional strain and stress. We ourselves are not yet through the one we entered with the Great War. Every one finds it difficult if not impossible to think calmly in times of great emotional appeal. It is this which makes tolerance in war and religion so difficult. As Sir Thomas Browne well said: "Men have lost their reason in nothing so much as their religion (and he should have added war) wherein stones and clouts make martyrs; and since the religion of one seems madness unto another, to afford an account of the rational of old rites requires no rigid reader." Nor is it only religion and war of which this is true. It holds for anything regarding which men feel strongly, and it is recorded that artificially produced emotional excitement is used among primitive people to stimulate belief in magic and animism, for incantations increase suggestion, heighten the illusion and hence forestall scrutiny and criticism.

Credulity is so prevalent even to-day as to escape comment. Indeed, it is the rule, scepticism the exception. We take conformity in all things for granted; non-conformity only attracts attention. This probably always has been and probably always will be so. But if this be true, then it must follow that man is far less a reasoning being than he has prided himself upon being and that most people still walk by faith rather than by sight.

Most thinking is haphazard and sound thinking an art which few acquire. We become reasoners only through painful experiences. We are born into, bred for and later yield to, if we do not actually strive for, conformity. Mass treatment and mass production also impose it. Our religious, our political and our scientific beliefs are prepared for us. We are bred dogmatists and only the Galtons protestingly ask: "Are we to understand that it is the duty of man to be credulous in accepting whatever the priest in whose neighborhood he happens to reside may say? Is it to believe what his parents lovingly taught him?" We grow up to accept things as they are, and credulity ever has forged the chains which scepticism later has had to break. Few indeed are they who shatter its bonds early and strike out boldly for themselves.

Conceptions which constitute credulity to-day may have been regarded as wisdom but yesterday. Yet the mental attributes which characterize a credulous person probably have remained the same and so have the criteria by means of which we judge it. The nature of credulity is unchanged and so no doubt is its cause. The credulous have formed a large group in all ages, but we are born neither credulous nor incredulous and one can not rightly speak of an instinct of credulity. One can be born credulous only in the sense that he lacks mental acumen, curiosity or initiative and it surprises one that Ward referring to Bain spoke of a "primitive credulity" as the leading fact in belief, and that James spoke of "a primitive impulse to affirm immediately the reality of all that is conceived."

Credulity is characteristic of the childhood of man and of civilization, and one might perhaps use its prevalence as an index of the intellectual status and perhaps also of the happiness of a people! Childhood is generally conceded to be a happy and a pleasant state, hence the more credulous a people, the happier it ought to be. A credulous man has few perplexities. "Is it not true," asks Pascal, "that man must be ignorant of the science of geometry if he is to be happy?" Erasmus, writing ironically, spoke in a similar vein when he said, "If anything could be known for certain would knowing it not interrupt and abate from the pleasure of a more happy ignorance?" However, we count those days great in the history of civilization in which the bonds of credulity were broken quite generally and new conceptions began to dawn upon the favored few among men.

We habitually associate credulity with ignorance and usually speak of an ignorant and a credulous age with pity. Perhaps, some happy day we may have the wisdom to erect monuments, in our hearts at least, to more of the pioneers of those great enlightening epochs in human progress when the emancipation of the human mind went forward apace —epochs in which links in the chains which man had forged for himself were broken, thus enabling men to speak freely even if they did not think very deeply or speak very wisely. It is not necessary, for example, to unqualifiedly accept the feeling of Rabelais regarding the preaching of his day in order to admire his audacity in declaring: "The less said the better. I never sleep at my case except when I hear a sermon or when I pray to God." It means much indeed for his time that he dared speak out, although Rabelais was an anatomist and physiologist as well as a literary man and hence perhaps unduly unresponsive.

It is not credulity regarding theological matters that has a special interest for me, although, to be sure, credulity in science often is a twin sister of credulity in theology. Although theology and science do not necessarily deal with the same topic, "many of us are taught from earliest childhood to invoke the saints" to further our own ends.

Credulity in scientific things has not been limited to those unacquainted with science. Nor have churchmen lacked scepticism regarding scientific matters. Men in the shelter of the church like Boyle and Newton maintained an encouraging scepticism regarding scientific matters. Others, like Pascal and Steno, were sceptical at first, then fell under the sway of theology and ended their scientific careers prematurely. Still others, like Sir Thomas Browne, were grossly credulous at first and unusually sceptical soon thereafter regarding the same things but without severing their relations with the church.

Environment no doubt played a part,

a very important one, in Browne's case, for it probably was the "Zeitgeist" which saved him. In Pascal's case, however, it was not only through the spirit of the times that his great intellect was lost to science, but through an intense desire for happiness which science did not seem to vouchsafe him, for he declared, "I spent a long time in the study of exact sciences, and I was disgusted to find how little compensation one can find in it. When I began the study of men I saw that they were not suited to it, and that I had wandered further from my proper condition in investigating them than the others had in neglecting them." But the difficulty lay not in science, for Kepler, Galileo, Newton and a host of lesser men found their greatest happiness there. The difficulty in Pascal's case probably was due to personal rather than to environmental causes.

Aside from the question of the origin of life and the destiny of man, there is no sphere in which credulity has played and still plays a larger part than in regard to health and disease. It is pitiable that such deep credulity persists regarding these matters even to-day when so much that is reliable is known concerning the human body and the infirmities from which it suffers. This so impressed the late Sir William Osler that in a public treatise, issued shortly before his death, he wrote: "In all things relating to disease, credulity remains a permanent fact, uninfluenced by civilization or education."

Osler repeated the same thought a few pages further on and among other things added: "Precious perquisite of the race, as it has been called, with all its dark and terrible creed, credulity has perhaps the credit balance on its side in the consolation afforded the pious souls of all ages and of all climes, who have let down anchors of faith into the vast sea of superstition. We drink it in with our mother's milk and that is indeed an even-balanced soul without some tincture of it. We must acknowledge its potency to-day as effective among the most civilized people, the people with whom education is most widely spread, yet who absorb with wholesale credulity delusions as childish as any that have ever enslaved the mind of man."

Nor was the medical profession exempted by Sir William, for he declared: "We doctors have always been a simple trusting folk! The blind faith which some men have in medicines illustrates too often the greatest of all human capacities—the capacity for self-deception."

Osler, who had been twitted on practicing medicine with "nux vomica and hope," in referring to organotherapy, wrote: "One is almost ashamed to speak in the same breath of the credulousness and cupidity by which even the strong in intellect and the rich in experience have been carried off in a flood of pseudo-science. This has ever been a difficulty in the profession." Indeed, one need not wonder that the laity far outdo the profession when men of the highest standing—even Academicians—in pure science to-day attest to the most apocryphal cures by pseudo-scientists and outright quacks.

Since St. Augustine well knew what "old wives' tales" were, it surprises one that this learned man believed that the flesh of a peacock never putrefies. Especially so since he derided some of these tales himself and also stated that he in turn was derided by God, "being insensibly and little by little led on to those follies, as to credit that a fig tree wept when it was plucked, and that the mother tree shed milky tears"; or that "had some saint eaten and mingled with his entrails, he should have breathed out angels; yea in his prayers he shall

assuredly groan and sigh forth particles of God, which particles of the most high and true God should have remained bound in the fig unless they had been set free by the teeth and belly of some 'sweet saint!'" Nor did Augustine believe in sorcery, for he says: "I remember, too, that when I decided to compete for a theatrical prize, a soothsayer demanded of me what I would give him to win; but I, detesting the abominating such foul mysteries, answered that if the garland were of imperishable gold, I would not suffer a fly to be destroyed to secure it to me." Yet, St. Augustine decried the belief in the antipodes and held that touching the bodies of martyrs "preserved uncorrupted for so many years" would heal blindness.

Sir Thomas Browne declared his belief in palmistry, tutelary angels, the philosopher's stone and the reality of witches. This strikes one with surprise, especially because he held that those who disbelieved in witches were not merely infidels, but atheists, adding, in the manner of Tertullian, that he was the more ready to believe a thing the more improbable it was and that the actual impossibility of an alleged occurrence is an evidence of its truth. Yet, but a little over a decade later this able and lovable man asserted in his "Pseudodoxia, or Inquires into Vulgar Errors" that there are only two pillars of truth, experience and reason, and that neglect of inquiry, obedience to authority and credulity are responsible for much error. This sounds strange indeed coming from one so steeped in theology that he had argued in all seriousness but a few years before, that he should not date his age from the day of his birth but from that of his baptism, because he did not exist before then. Although this was a well-known and current theological conception, I can not adopt the attitude of apologists who see nothing contradictory in this attitude of Browne's, for even if the word existence is used in a wholly different sense, to reckon his chronological age from baptism nevertheless remains nonsense. The assumption of water-tight mental compartments can not save it and as Boutroux has well said: "If science and religion are to continue to co-exist, it seems opposed to the conditions of modern thought to admit that this result can be brought about by the so-called 'watertight compartment' system which, at the present time, is frequently extolled and considered possible." A thinker may say so, but it does not therefore follow that he actually can so confine his thoughts. It seems to me that the day never was when real thinkers could "hold religion in one compartment of their minds and their modern world view in another." A daring intellect does not, nay can not, build mental fences for itself.

After discussing a long list of errors of credulity, Browne concluded by saying: "Many others there are which we resign to divinity and perhaps deserve no controversy." He was thirty years old when he wrote the "Religio Medici" and forty-one when he wrote the "Pseudodoxia." It is true that his was not a very outstanding intellect, but he nevertheless was a man of rare parts, of varied learning and of wide experience. Earlier in his career he apparently had followed Bishop Hall's dictum that "not a curious head, but a credulous and plain heart is acceptable with God." His complete about-face can be accounted for by assuming that the times in which he lived shaped his attitude as they do our own. No one is independent of his day, least of all of the present, and it may be recalled that during the war one of our highest government officials declared that the United States had been chosen by God

"to greatly influence, if not to determine, the course of future events." It would be interesting to know whether or not this gentleman held as firmly to his belief in the intervention of the Lord in human affairs after his defeat as a presidential candidate!

Since Pascal assigned a similar crucial rôle, as this politician assigned to our country, to "a little piece of gravel in Cromwell's bladder," we should not, I presume, doubt this confident verdict regarding our country's "manifest destiny." It may be recalled that Luther was afflicted in a manner similar to Cromwell and that the removal of his stone too might have changed the course of history. Hence I make bold to suggest that the influence of urinary calculi on history might be a fitting subject for some young aspirant for the doctorate.

In Browne's case the change in mental attitude was from a condition of extreme credulity to one of frank inquiry; in Pascal's case it was the reverse. The difference in the result, it seems to me, does not lie wholly in the differences of the times, but largely in the men themselves. I am reminded, however, that Matthew Arnold held that the differences of opinion and character in men are not organic, but wholly the result of a difference in environment. But fortunately there are innately curious just as there are innately confiding individuals. "Some men and thinking men too," says Buckle, "never have those vexing thoughts" of doubt. They close the door of doubt, or better never open it. They do not give "stabbing truths" a chance to affect them, but rather "trust in false things and nourish the wind," as St. Augustine said.

Carlyle thought that "there are only a few reasoning mortals, here and there," and Mill in his diary declared that there was neither thought nor knowledge in England. He declared: "The characteristic of Germany is knowledge without thought; of France, thought without knowledge; of England, neither knowledge nor thought."

"The Germans, indeed, attempt thought, but their thought is worse than none. The English, with rare exceptions, never attempt it. The French are so familiar with it that those who can not think at all throw the results of their not-thinking into the form of thoughts."

It may be recalled that Lecky held that it was not arguments, but habits of thought resulting from common sense, that overcame the belief in witchcraft. But common sense surely is the product of experience and of reason based upon it. New habits of thought can arise only on the basis of new experiences, or from desires in answer to needs. It does not seem possible that a whole people is likely to, or even can, change its habits of thought in any brief period of time, save through a great and universal experience, for deep thinking is not a universal trait of mankind. It takes resolution and effort to think and there is considerable truth in the statement of a recent writer that "most people would rather sicken and die than think," and he added, "they do." Indeed, "it is much easier to believe than to doubt, for doubt connotes thinking and the expenditure of energy and often also the disruption of the status quo."

Few of us can break the chains that bind us, and still fewer wish to do so; and after all perhaps Shaw was right when he said that the cleverest man will believe anything he wishes in spite of all the facts in the world. However, I have never felt much sympathy with the old saying: "Populus vult decipi," for every one but a fool resents being trifled with. Worthless stock causes rejoicing only as long as its true nature remains

unknown. People like to deceive themselves only regarding unwelcome things, and then only provided that the truth or reality of them can not be established. Did they know for a certainty that disillusionment would follow inevitably and swiftly, few indeed would wish to be deceived regarding anything. No one is flattered by public disclosure of the fact that he has been duped, least of all that he has duped himself, but it is so easy to believe when the wish is father to the thought. I desire to get well, therefore, I will get well. Credulity easily congeals into prejudice, and as Tyndall put it: "The drugged soul is beyond the reach of reason. It is vain that imposters are exposed, and the special demon cast out. He has but slightly to change his shape, return to his house, and find it empty, swept and garnished."

It is especially interesting that religion has often been advanced as a safeguard against credulity, but it would seem more likely that religious beliefs, which are accepted upon authority, must tend to lessen the spirit of inquiry in regard to other matters also. It is reported, for example, that the Baloki had no faith in their medicine men before the missionaries came. Yet, Mill wrote:

> "It is sometimes said that religion is the only preservative from superstition; that unbelievers and unbelieving times are the most indiscriminately credulous; 'A godless Regent trembles at a star,' the popular delusions (Mesmer, Cagliostro, etc.) of the time preceding the French Revolution: mesmerism, table-turning, etc., at present. But the truth is, credulity and love of wonder are so natural to man that they always (hitherto) run riot when they have only reason to control them. Credulity has never yet been held in check, but by a regulated credulity—a faith of some sort which excommunicates all wonders but those which it can use for its own purposes. Those who throw off this faith do not thereby become altered in the general texture of their understandings; they remain as credulous as ever, but being no longer preoccupied (and the appetite for wonder blunted) by one set of delusions, they are now open to all others."

Were this true, then all nations must have been very irreligious during the Great War, for anything and everything was reported and believed. We were alleged to have poisons so potent that whole cities could be swept away as with a breath. To hear a rumor was to believe it, to believe it was to accept it as truth, and to accept it was to act upon it quite regardless of the consequences.

In spite of the beneficent fruits of improved means of communication, the introduction of printing, the telephone and telegraph, wireless telegraphy and so forth, these make credulity more contagious, for they not only excite wonder but help to reveal the credulous everywhere and make contact with them and between them easier. Dame Rumor now-a-days moves faster than the wind and times of great awakening, such as the Renaissance, are said to have been followed by epidemics of credulity. Great discoveries create an impression that all things are possible and in the present so-called scientific period, Abrams and Hatfield become popular heroes and the public has little sympathy with scientific disbelief regarding them.

Nor is credulity entirely absent from scientific laboratories. We can grow tissues under the microscope, therefore, we have life in a test-tube. Physiologists talk about colloidal systems and some of them claim to know what life is. If we scientists delude ourselves, why rebuke the masses who are deluded by others most of the time and if it be true as Tout claims "in no period are the critics an exception to the general rule of unthinking credulity," no one would seem to be exempt.

Although there undoubtedly are credulous natures, ignorance seems mainly responsible for the prevalence of credulity in the public and in the individual. This does not imply, however, that educated persons may not be deeply credu-

lous, for no one can know enough to ensure wise action in all things. Safety lies in an awareness of one's ignorance and in relying upon those who do know about matters that one does not. In this lies not only the salvation of the individual but also that of democracy itself. The eclipse and the rainbow ceased to be portents of evil as soon as they were understood. As Hobbes well said: "Ignorance of natural causes disposes man to credulity, so as to believe many times impossibilities; for such know nothing to the contrary, but they may be true, being unable to detect the impossibility. And credulity because men like to be hearkened to in company, disposeth them to lying; so that ignorance itself without malice, is able to make a man both believe lies, and tell them; and sometimes also to invent them." Hobbes's opinion receives some confirmation from Mill, who thought that there is more of lying than of self-deception in spiritualism.

There have been those who have held that credulity is a conserving social force. By doing something to produce rain Hatfield may have lessened the anxiety of some and increased the hope of other ranchers. Ceremonies and prayer during illness or war may accomplish similar results and may keep the idle and anxious occupied and thus protect the rest by keeping the former from mischievous and disturbing thoughts. This may be good doctrine for children and the masses, but let it not be forgotten that organized credulity—as when it licenses cults to deal with public health or opposes the use of the dead for help to the living—is as destructive a social force as was the belief in witchcraft. It was wisely said that "black magic and red religion have been extremely anti-social at all times" and that no "baser delusion (than superstition) ever obtained dominion over the weak mind of man." Indeed, no one can tell what heights the human race might have reached by today had it never been burdened with unquestioning credulity. I presume there should be no unpardonable crimes among men, but if there be such then shackling the human mind should head the list. A sound mind in a sound body is a worthy ideal indeed, but a sound mind is of little use unless it be free, even if it remain true, as Heine thought, that liberty is but a cruel dream.

PROGRESS

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PROGRESS as a biologic and social fact and the idea of progress as a social force are distinct phenomena. The fact of progress is disputed; the idea of progress as a dynamic element in modern society is generally accepted.

It is perhaps significant that the origin of the idea of progress about the middle of the sixteenth century, and the acquisition of its present social potency in the latter part of the nineteenth, was each associated with an event that gravely wounded the pride of the race. Copernicus proved that the earth was not the center of the universe, but a very insignificant part of its own solar system. In 1858, Darwin published his "Origin of Species," ushering in the theory of evolution by which man was degraded from his proud position "a little lower than the angels" to a more humble rank a little higher than the apes.

Before Darwin, man, looking backward over his racial history through the spectacles of a religious dogma, saw a Garden of Eden or some other golden age of innocence and happiness. But with the onset of a sort of racial presbyopia, these spectacles lost their power, and man saw in the long dim vistas of the past not a beautiful garden inhabited by a perfect man and woman, but an uninviting Paleozoic swamp in which ugly reptiles disported their unwieldy bodies. This look into the long past, at first so disconcerting, was not without its useful effect. When he awoke from his dream of a past golden age and became dimly conscious of his own ancestry, the idea of progress took on a new meaning and acquired a strange potency.

Progress began with the appearance of life upon the earth. Whatever the fundamental nature of life, with its advent matter that became living acquired an activity that was largely unpredictable as to direction, mode and strength. The realm of the organic or living was separated from the inorganic or nonliving. The inorganic world is intensely dynamic at least within narrow fixed limits of the atom; but it lacks individuality. The organic or living world exhibits spontaneity and an orderly system in the midst of an almost unbelievable multitude of living beings. Individuality, that quality that marks off one being from another of its kind, came upon the earth with life.

The second step in progress was made when living organisms became more complex. Instead of a single cell some of them came to be composed of many cells, some on the surface near the source of supply of nutriment, others in the more central parts where the needed nourishment could reach them only by diffusion through the more superficially located cells. The needs of increasing complexity were met by the formation in the body of different organs, composed of highly differentiated cells and with specialized structure and function.

With the increasing complexity of living organisms and the division of labor among the organs of the body, there entered a new factor of progress, namely, death. Death became a biologic necessity; one of the fundamental determinants of progress. "The sure-enwinding arms of cool enfolding death" are quite different when considered from the standpoint of biology and progress,

from the dreaded, inexorable, dissociating destiny that death becomes to the individual. Goethe remarked that "death is Nature's expert device for producing an abundance of life." To "yearn for speedy death in full fruition" is not an unworthy biologic desire. Swinburne had something of the biologic viewpoint in his "Garden of Proserpine" when he wrote:

From too much love of living,
  From hope and fear set free,
We thank with brief thanksgiving
  Whatever gods there be
That no life lives forever;
That dead men rise up never;
That even the weariest river
  Winds somewhere safe to sea.

With the increasing complexity of structure and size of organisms and with the advent of death, life became more abundant and aggressive without being in the way of its own progress. Each living creature leaves behind it an abundance of seed capable of reproducing its kind and making possible useful variations. This is, as Huxley has so graphically said, "a Sisyphean process, in the course of which the living and growing plant passes from the relative simplicity and latent potentiality of the seed to the full epiphany of a highly differentiated type, thence to fall back to simplicity and potentiality again."

Animal life became differentiated from vegetable life, and between these two forms was intercallated the interrelated, useful and even indispensable group of bacteria. With this triad of living types, there was instituted that marvelous chemical mechanism, the nitrogen cycle. Plants developed the unique and potent substance chlorophyll, by which they use the sun's rays to build up very complex chemical compounds from such simple substances as the nitrates, carbonates and water of the soil. In plants, protein, a complex substance which contains nitrogen and is essential to animal life, but which animals are incapable of building up from its elements, became abundant. This made possible the origin, continuance and further evolution of animal life. Animals transform plant proteins into the more complex animal proteins. But animals reach their threescore years and ten or its racial equivalent and die. Bacteria then decompose the complex animal protein, breaking them down into simple nitrates, carbonates and water to be used again by plants. The nitrogen cycle thus became an essential of all further progress.

Other attainments of animal life that have been fundamental factors in this progress are the acquisition of a body, with its component organs, among which the labor of maintaining the various functions of living matter has been distributed; bilateral symmetry of body conducing to greater freedom and better coordination of movements; and the development of a backbone making possible the upright posture, and freeing the fore-limbs for uses other than locomotion. A distinguished paleontologist has described as "the earth's most dramatic moment" that day when the first animal crawled out of the Paleozoic ooze and, by means of a workable mechanism for guaranteeing its oxygen supply, succeeded in maintaining itself on dry land.

Some of the back-boned animals developed a mechanism for regulating body temperature. The temperature of the so-called cold-blooded animals is always approximately that of the medium in which they live and therefore varies with the season and even from day to day. The acquisition of a means of maintaining a constant body temperature avoided the necessity of an animal's being one day alert and active and the next sluggish and inert. This introduced a possibility of progress of incalculable impor-

tance. Upon it depends man's freedom from slavery to changes in the weather, the sequence of the seasons and the variations of climate.

The differentiation of the sexes led to the liberation and education of the emotions; so that men came to love and to hate, to pity and to curse, to feel shame and to express anger, to seek pleasure and to find pain. Animals developed eyes to see and ears to hear and other special senses by which the slowly evolving personality within learned the beauty and the ugliness, the sweetness and the bitterness of its environment.

But the greatest biologic achievement in the possibilities it entailed was the acquisition of a central nervous system. This slowly evolved through an ascending scale, the climax of which has been reached in man with his relatively huge brain incased in a protecting skull, and a long spinal cord inclosed in a protecting spinal column. The cortex of man's brain, if spread out, would cover not more than two square feet, and is said to contain 9,200,000,000 nerve cells, which, if got together, would weigh less than half an ounce. And yet this thin layer of gray matter is "the material theater of man's intellectual life."

The appearance of life upon the earth; the acquisition of a body, especially one with bilateral symmetry; the intervention of death as a biologic necessity; the institution of the nitrogen cycle; the achievement of a mechanism for maintaining a constant body temperature; the differentiation of the sexes; the development of the special senses; the evolution of a central nervous system—these are some of the foundations of biologic progress.

The outstanding feature in all this is an increasing complexity of structure and function that gives to the living organism an increasing capacity for dealing with its environment. The most important of all these elements of biologic progress is the acquisition of a central nervous system, the integrating mechanism by which all the different organs and functions of the body are organized into a homogenous system with unified control. This system, with its increasing intricacy of structure, is the basis of behavior. In the ascending scale of animal life, behavior becomes more and more complicated, acquires more and more the attributes of intelligence and connotes an expanding mastery of environment. With the advent of life upon the earth, the evolution of the multitudinous species of animals and plants began. With the development of the human mind, history, which deals with societies of rational beings, originated. As Thompson remarks, "The great difference between human and animal evolution becomes plain when we observe that man is aware of his own evolution and seeks to direct it according to his own ideals."

The evolution of any species is the result of the interaction of a static factor, heredity and two dynamic factors, variation and selection. There has come down through time a stream of germ-plasm in and through which heredity has operated. It (heredity) is the inertia that tends to prevent change; it is that which causes living beings to reproduce their kind. But in spite of the stabilizing influence of heredity, variations have occurred, giving rise to new species. Variations are of two kinds: those which take origin in the germ-plasm, such as the color of the skin and the shape of the foot, and are therefore deep-rooted and fundamental, and are reproduced in succeeding generations; and those which are due to acquired changes in the body or modifications of its activities without corresponding alterations in the germ-plasm, such as smooth-shaven faces, the performance of certain religious rites, and are therefore not inherited by the

offspring. The former are the foundation of the development of new species; the latter are important factors in the evolution of human society, being transmitted from generation to generation through the force of individual habit and social custom.

Man, as a species of living organism, with his mechanically efficient body and his highly developed and integrated central nervous system and all that they connote, represents unquestioned biologic progress. This is the result of a long series of primary changes based upon fundamental alterations in the prodigiously long stream of germ-plasm extending back at least to the origin of vertebrate types. Man's physical form appears to have become stabilized, so that further anatomical changes seem unlikely. The future progress of mankind must, therefore, be the result of societal as distinguished from biologic evolution. Social metamorphosis has resulted and will continue to result from the action of forces quite different from those which instituted and perfected man's present physical form. Human anatomy is dependent upon the fundamental and not readily changed qualities of human germ-plasm. Social organization is based upon a great body of tradition transmitted at first orally and later by more accurate and permanent written and printed records. Man can not by taking thought add one cubit to his stature, because that is effectively guarded by the laws of heredity and of economy of growth. But he can, by taking sufficient thought and by the exercise of an adequate force of individual and collective will, modify his social system to meet the demands of gradually changing conditions.

The evidence of biologic progress is abundant and convincing, if we consider as progress that series of changes which have enabled animals to live a freer existence, to liberate themselves gradually but steadily from the bondage of their environment, to receive stimuli through an increasing number of sense organs, and to integrate and interpret these sensations through an increasingly complex central nervous system; in other words, to live a life richer in content and more exuberant in expression. But what of social progress? Has anything happened to man as a social unit in an organized society that is at all comparable to what has occurred to him as a biologic unit in the animal kingdom?

The first requisite of human progress as distinguished from biologic progress was the formation of associations of human beings or social groups. Blood relationship was perhaps the first bond of such organization. As the family grew into the clan and the clan into the tribe, a further sanction became necessary. For this purpose, it was essential to have a law which man must respect and an administrator of that law to whom men could pay deference. In order to fix and confirm an inherited, loose social organization, not equality before the law was needed, but obedience to the law.

War and religion established this obedience. War fostered the rapid reproduction of the race and implicit obedience to the accepted law. Religion furnished a supernatural sanction to social organization. Primitive religions, with their Phoenician Molochs and Aztec Huitzilopochlis, were incredibly cruel. They put upon the fixed law of the tribe a sanction so terrible that none dared ignore it. The punishments for nonconformity and infractions of the accepted ritual were most drastic and appalling in their severity. The individual who failed to show proper respect for any of the gods not only endangered his own life, but jeopardized the lives of his fellows. War and religion thoroughly cemented the "cake of custom," and thus

introduced solidarity into the social organization. But while rigidity of social structure has had its uses, it is only those nations which have broken through this "cake of custom" that have become progressive in the modern sense. This emancipation has occurred only in western nations, and in the last two hundred to three hundred years.

Under the conditions of modern civilization man has been compelled to take steps to annul the law of natural selection. It has been the only means by which the race could survive and still retain the vast social heritage that has been accumulating at a progressively increasing rate for generations. Upsetting any biologic process is a dangerous expedient. Nature thwarted exacts drastic penalties. The way of modern nations is beset with dangers, some of which are as old as social organizations, others distinctly new. The increasing complexity of group relationships has given rise to problems that demand the greatest intellectual capacity for their solution. Heredity is the only known biologic force capable of furnishing this social necessity of good brains. And yet modern society is wasting its supply of this irreplaceable material. Reservoirs of fresh germ-plasm, in the form of huge primitive populations with which to rejuvenate a decadent and declining race, do not exist in any abundance.

The mixture of totally unrelated human stocks almost invariably yields an inferior product. Miscegenation would be a cure worse than the disease. The "true-born Englishman" is, on the whole, a very desirable blend in spite of the bizarre, but still racially related elements of which, according to De Foe, he is composed.

These are the heroes that despise the Dutch,
And rail at new-come foreigners so much;
Forgetting that themselves are all derived
From the most scoundrel race that ever lived;
A horrid crowd of rambling thieves and drones
Who ransacked kingdoms and dispeopled towns;
The Pict, and painted Briton, treach'rous Scot,
By hunger, theft and rapine hither brought;

Norwegian pirates, buccaneering Danes,
Whose red-haired progeny everywhere remains;
Who, joined with Norman French, compound the breed
From whence your "true-born Englishmen" proceed.

Whatever else this "compounding of the breed" brought into England and thence to America, it did furnish a mass of excellent germ-plasm, a solid basis for a heredity with a high potential for social and intellectual capacity. That the best of this will ultimately be drained off and irrevocably lost as a result of the present differential birth-rate among the different social groups, leaving only the "scoundrel-race" portion, appears to be a reasonable certainty, unless mankind as an organized society takes some steps to prevent it. The human race may yet become "a penniless lass wi' a lang pedigree."

That artificial selection in the form of eugenics is the proper solution of the problem we have no absolute assurance, because there is no known standard by which to determine what heritable characters are best fitted for guaranteeing modern social progress. Perhaps any form of eugenics would be no worse than the present confused mixture of breeds and even of races. The criteria for fitness for survival are not the same under modern and under primitive conditions. Now that the human hand has been advanced from the lowly position of laborer to the more dignified status of superintendent of a tool, mere brute power and muscular strength are not so essential to survival as in earlier times.

Instead of being a slave to nature, modern man has discovered her secrets and has learned to make her power serve his individual and collective ends. Great

social and political development always requires a commensurate supply of productive energy. The only sources of such energy known to the ancient world were slaves and, to a less extent, domestic animals. They had no artificial forces to apply to production and transportation, and the only natural force effectively harnessed by them was that of the wind as applied to marine transportation. Their chief if not their sole means of meeting the demands of political and social expansion was by the extension of the system of slavery. Modern man, under similar conditions, increases the number and varieties of his machines.

By the development of language and by the invention of writing and printing, man has accumulated his present enormous and ever-increasing social and intellectual heritage. It is now possible for one generation to learn from the successes, failures and mistakes of previous generations. This lends interest, if it does not always add profit, to life and the mere process of living.

Man's discovery of means of emancipating himself from the tyranny of climate; his acquired ability to use the forces and resources of nature for his own purposes; his development of forms of social organization and of government that sanctions and encourages the unfolding of the latent potentialities of the individual members of society; his transformation of religion from a crushing social force based upon terror of the supernatural into a personal belief that does not insult his slowly developed power of reason—all these indicate that man has made social progress since he acquired a mind, as great, in its way, as the less readily disputed biologic progress of which man himself forms the capstone.

But is this alleged progress real or imaginary? Is it permanent or ephemeral? Pessimists insist that the idea of progress is an illusion, a tantalizing mirage on the desert of human existence. They assert that modern civilization will follow that of Babylonia, Egypt, Greece and other ancient peoples into a thoroughly deserved oblivion. The achievement of civilization has been a Sisyphean task. For the pessimist it will never be otherwise. Cogent reasons can be advanced for hoping that he is right. The uncertainty of constant striving is more enticing than the monotony of acquired perfection. It is useless to dispute this assertion of pessimism because neither side of the question is capable of such proof that the talismanic letters "Q. E. D." can be written after it.

Certain observations, however, are pertinent. In ancient times, nations rose to greatness by conquering and subjugating others. A civilization of great brilliance largely disappeared when the people which gave it origin became the oppressed subjects of a militarily stronger nation. As a result, great nations and their great civilizations were, in ancient times, generally solitary and segregated, and not contemporary or coexistent. "Fuit Ilium" became the epitaph of every conquered nation and its intrinsic civilization. Its fading inscriptions quickly became a sort of "gilded halo hovering round decay." At present, there are at least six great nations, or groups of related nations, each with its characteristic type of western civilization. Man long ago ceased to function effectively as an individual unit and became merged in the greater and more powerful and efficient group. This transformation of man from a troglodyte to a gregarious creature may have been an important factor in his survival as a species. It was certainly the basis of his developing what we call civilization and of his acquisition of the enormous heritage of social customs and intellectual capital that is handed on from genera-

tion to generation. Internationalism in some form may, indeed has already, become to the separate nation what society long since became for the individual man. It is not, therefore, a foregone conclusion that western civilization will follow its predecessors into the great maw of time and cease to be.

The outstanding feature of the past century has been the whirlwind progress of science. This has induced greater changes in any decade of this period than had occurred in any one or more millennia of past history. Change always requires adjustment. It is not the extent, but the rate of change that determines whether suitable adaptations can be instituted. This applies to social organizations as well as to individuals. Henry Adams found it necessary to reeducate himself three times in order to harmonize with his environment, completely altered by the general application of scientific discoveries and inventions. The public mind is still so polarized that its lines of force run in much the same direction as in prescientific days. Individual habits are difficult to change. But social customs, which are the habits of organized society, require generations for alteration. Human nature, made up of social customs and individual habits almost hopelessly enmeshed and entangled with the long thread of human heredity, has perhaps not been materially changed since the last glacial epoch. At best, civilization is little more than a mask with which to cover the ugly face of the savage inner man.

And yet man, composed as he is of a mixture of miscellaneous passions and instincts inherited from prehistoric and possibly from prehuman ancestry, has learned from science to build for himself mechanical devices wherewith to multiply his powers a thousand-fold. Much of his effort in this direction has been turned to the making of implements of destruction beside which Jove's thunderbolts were mere toys. The prospect of this partially tamed savage "running amuck in the full panoply of civilization" is frightful to contemplate. This Tubal Cain whom we call civilized man is a skilled "artificer in brass and iron," but he still "speaks as a child, understands as a child, thinks as a child." He acquired the knowledge with which to fashion for himself the powerful and dangerous instruments of modern science before he developed the judgment and wisdom to use them wholly for his own good. He has learned to outrun the horse and to outfly the eagle, but in the solution of the new problems these strange powers have brought, he progresses at the speed of the sluggish tortoise. He sends his thoughts around the world with the speed of light, while his thinking is still attuned to that of his forefathers, who were accustomed to learn of battles fought and won weeks after treaties of peace had been signed. He has invented machines by which he can, in a day, destroy a whole city, without attempting to curb those inherited instincts and acquired emotions that demand their employment. The astronomers have taught him that the great blue vault above him is not the under surface of the floor of heaven upon which rests the throne of an omnipotent God awaiting the opportunity to cast him into a burning hell whose chimneys are the earth's belching volcanoes. He is coming to believe that he lives in a universe devoid of both a physical heaven and a physical hell, without formulating for himself a sanction for his conduct to replace that of postmortem rewards and punishments formulated for him by his spiritual advisers. He enjoys the luxurious ease and physical comforts of modern civilization but is unwilling to exert his mind sufficiently to discover the means of averting the dangers which

threaten his social organization and even his race. When dangers become too imminent he is too willing "to grasp the skirts of happy chance" and to adopt some expedient which can only postpone the day of final catastrophe. Man is the earth's most arrant opportunist.

From him "hope still tells a flattering tale." He is loath to believe that the modern scientific equivalent of the ancient "gorgons. hydras and chimeras dire" still beset the path of the race. He hopes somehow to "invert the miracle of Circe." The unhappiness of the world, he believes, must in some way be banished and the misery alleviated. To further this end, man has invented the modern system of charity. This device, energized by sentiment and poorly lubricated with reason, has worked harm both socially and biologically that is hardly balanced by the good that it has done. The promiscuous and illogical giving of aid to the unfit and discontented has brought individual and social disaster since the Roman mobs were given free corn and free entertainment by their uneasy emperors. Rational charity is both desirable and necessary under modern social and economic conditions. But charity, born of vanity and nurtured on self-appropriation, is a curse both to him who gives and to him who receives. John Reed thus aptly described this type,

> And here's the rich man fidgeting beside us,
> Who tries to be Maecenas, and is Midas;
> And from his talk it presently appears
> That every Midas has an ass's ears.

Present social conditions, generated by the scientific discoveries and the resulting multitudinous inventions of the past century, have led to a dangerous over-specialization. Biologic over-specialization has frequently caused extinction of species. The fossil remains of many extinct animals show this phenomenon. The saber-toothed tiger, the mammoth, the gigantic saurians of Mesozoic times, all exhibited some form of this condition. A high degree of specialization may mean absolute dependence upon some peculiar condition of food supply, the elimination of which leads to the extinction of the species; or the over-development of some "useless dominant organ," such as huge tusks or antlers, violates the law of economy of growth and the species disappears.

Modern society is dangerously over-specialized in the distribution of population and in industry. Dangerously, because this set of new conditions is apparently irreversible, for human life has come to be dependent upon them. "The rise of great modern cities has been due to, first, the industrial revolution which made possible the growth of vast manufacturing centers; second, the rapid development of international trade, stimulated by recent inventions and by improvements in transportation; and third, the increase of population, which itself is an outcome of the new inventions and of the industrial revolution." Urban populations are not self-supporting. They are dependent for their food supply on an efficient system of transportation and for water upon an elaborate plexus of pumps and pipes. A partial breakdown of either would cause suffering; a complete failure would mean disaster.

Under the old system of production, the worker was a true craftsman; under the modern system, he is part of a machine. The modern system guarantees efficiency and vastly increases production, but "tends toward the standardization of mind and the elimination of intelligence." The older system yielded less product but developed personality. "They are happy men whose natures sort with their vocations," said Bacon. Men who will stand for eight hours a day and monotonously screw a nut on one particular bolt as pieces of machinery slowly pass in endless pro-

cession may be happy, but they will never make social progress.

The population of the world, increasing at a prodigious rate since the beginning of the industrial revolution, has not yet reached such magnitude that it cannot be fairly easily supported by the modern methods of agriculture and transportation. The present number of people could not, however, be sustained by the methods of agriculture and the means of transportation of a century ago. Modern civilization is built largely upon a foundation of coal and iron. It can continue to exist only as long as its foundation endures or suitable substitutes found for the elements that compose it. The extinct civilizations of the past at least left man's natural resources intact. But the bacchanalian fervor with which the human race in its present state of obfuscated and pot-valiant civilization is now expending the earth's irreplaceable mineral wealth impels one to wonder what is to follow this period of debauch when the supply of inebriating drink has been exhausted.

All these gloomy observations lead to certain more fundamental considerations of this modern phenomenon called progress. Man has accomplished and gained much since he acquired a mind as a result of those biologic processes of variation and natural selection by which he developed his complex brain. Is he, like a drunken gambler with fate, to lose it all? He certainly holds the key to his own future. In the past he has advanced; he has improved himself; he has acquired a material and intellectual heritage that might well excite the envy of the dwellers on Olympus; he has formulated for himself and successfully executed designs on the trestle-board of life so ambitious that former generations would have considered them impossible of accomplishment except by superhuman aid. The universal wish for superhuman strength that was father to the thoughts which created Atlas, Hercules and other mythical giants of antiquity, modern man has realized by his invention of machines. The major part of these achievements has been consummated since he conceived the idea of progress.

Since its conception, the content of the idea has varied with the changes in the intellectual medium which it has bourgeoned. The earlier thinkers on this subject, Bacon, Descartes and others, considered only progress in knowledge; Hegel and Comte added a spiritual component; modern science has given it a materialistic element. Social and intellectual characteristics of the different periods have paralleled the variations in the content of the idea of progress. In the first period, Swift and Pope wrote biting unemotional satire; in the second, Victorian authors catered to prudery; in the third has come the literature of crude realism and a crude disillusionment. In the earlier periods, the fact of progress was widely accepted as established truth. At the present time its existence is seriously questioned even by those who admit its value as a stimulating idea.

Before this idea could become dynamic, man had to rid himself of the illusions of finality and perfectibility. All the Utopias have been peopled by beings who possessed those qualities which, in the conception of the author, constituted a perfect man. The ideal of Utopian progress is the achievement of a state of perfection. But progress considered as the attainment of a fixed stable good, as the performance of a definite sum which lessens by that much the total effort required to reach the ultimate goal, *is* an illusion.

Mankind, until this modern age, has been obsessed by the idea of finality. His place and fate were unalterably fixed

and no effort on his part could change them. He must not inquire too curiously into the forbidden secrets of the gods, nor attempt too persistently feats reserved only for the gods. The stories of the Garden of Eden, of Prometheus, of Icarus, indicate the attitude of apprehension assumed by the ancients toward the conquest of nature. Their gods were both jealous and prudent, for man has always been audacious.

> Man finds no feat too hard or high;
> Heaven is not safe from man's desire.
> Our rash designs move Jove to ire,
> He dares not lay his thunder by,

said Horace. But modern man no longer fears the gods. He is not frightened by Jove's thunder and would laugh at the petty shafts with which Apollo slew the children of poor Niobe. To the ancients there was a fixed order in the universe. Human progress to them would mean the breaking down of the limits with which man had been encompassed, and therefore unthinkably audacious and perilous. Modern man thinks of a fixed order in the universe as an expression of the immutability of the laws of nature. Within the limits of those laws he has assumed the right to use the forces and materials of nature in any way and to any extent he chooses in the furtherance of his own preconceived plans. He therefore presumes to violate the tree of knowledge and the sacred reaches of the upper air with impunity.

Human progress, as distinguished from biologic progress, has been defined as the development and economy of forces—force being anything that does or helps to do work. Such progress could only be achieved by rational beings. And yet relatively little of man's advancement has been the product of planned, intelligent guidance. Nevertheless, man has progressed; even though his progress has been extrinsic, that is, due to artificial changes in his environment including the increased store of transmitted experience, rather than intrinsic and due to changes in the nature of man himself. Perhaps, therefore, Professor Dewey is right when he insists that "till men give up the search for a general formula of progress they will not know where to look to find it."

It is useless to attempt to formulate an ideal of the future progress of the race. There are too many contingencies which can not be forecast. Man, as a race, has been and is resourceful. He has had curiosity, eagerness, love of action, endurance, hope, simply because these qualities are a part of his make-up, not because of his taking thought of them. The story of his past, read as a mere story, and his present propensities viewed too critically, are not especially promising. "History has been defined as a process of rebarbarization." Man has repeatedly lapsed into barbarism or something akin to barbarism. But somehow, each time this has happened, his innate hope and eager curiosity and love of action have stimulated him to rise to something better. This rehabilitation has not been inspired by an ideal of some unattainable infinite goal of good. It has been accomplished by the study of the needs and possibilities of the actual situation and by actions suited to those possibilities and needs.

The foundation of human progress is, and perhaps will always be, the nature of man himself, and this has apparently remained unchanged for at least many thousands of years. The material basis of that nature is in his complex brain which is the material theater of his versatile and active mind. With the apparent evolutional stabilization of the structure and functions of man's body, which determines and fundamentally influences his spiritual and intellectual activity, it does not appear likely that human nature will, in the future, un-

dergo any very deep-seated intrinsic change.

No attempt is made, therefore, to formulate any ideal of progress or to picture another Utopia. Progress, biological, social and perhaps spiritual, has been achieved. Further advance will be the result of the same factors which have been responsible for it in the past. Those factors are inherent in the nature of man himself. Such progress need not be uninterrupted and will not bring freedom from cares and worries and fears, for it will not mean the attainment of perfection. It may never mean happiness for the same reason. But it will afford the pleasure that goes with accomplishment and the elation that accompanies the stimulus of an unattainable goal.

The mental reaction to such a view will depend upon the individual attitude toward the possibilities of human kind. It will not satisfy one addicted to pessimism, for his thought of the future of the race is that of

A sob, a silence, and a gasping spark;
A word that, spoken, cannot be unsaid;
A doom that, uttered, leaves the whole world
dead;
Ashes and smoke, and then the final dark.

Nor will it accord with the too buoyant and uncritical faith of the Pollyannas and Pippas, who hopefully reply to the jeremiads of pessimism.

O, yet we hope that somehow good
Will be the final goal of ill;
To pangs of nature, sins of will,
Defects of doubt and taints of blood.

This conception of progress places the responsibility for the future upon man himself, and yet furnishes a rational basis of hope for the future of the race. It supplies the stimulus of definitely fixing responsibility for that future. Man has been given his opportunity. Justly, he can ask no more.

THE FUTURE BALANCE OF LIFE[1]

By AUSTIN H. CLARK
SMITHSONIAN INSTITUTION

WHAT is to be the future balance of the animal life upon the earth? Will man remain supreme, continuing to hold his own against his numerous competitors, or will the Age of Man give place to another age in which the human race shall play a minor rôle or perhaps wholly disappear?

In Mesozoic times the reptiles were the dominant living creatures of the earth, but their supremacy came to an abrupt end with the end of the Cretaceous. Why this occurred we do not know.

The Age of Reptiles was succeeded by an Age of Mammals, which culminated in the Pleistocene.

With the disappearance of the great hoofed animals, especially the grazing kinds like the wild cattle, the wild horses and the bison, extensive cultivation of the soil was possible, and man increased in numbers and in influence until now he reigns supreme.

The disappearance of the great herbivorous mammals was possibly partly due to man himself through his increasing skill in the manufacture and the use of weapons. But probably it was mostly due to causes still unknown, for in North America there is no evidence that man played any appreciable part in the extermination of the very numerous horses, the elephants, the mastodons, the various kinds of camels or the ground sloths.

What are the conditions at the present time? The world to-day is dominated by four different types of life which are distinguished from all other types of life by having certain characters in common. These common characters are (1) independence of the temperature and the humidity of their environment, and (2) exceptional ability to travel.

First, we have man. Man in his bodily structure is a mammal. But, excepting anatomically, it is not possible to consider man in the same light as the other mammals, even the more or less man-like apes. Man's use of clothing and of fire render him independent of the temperature of the locality in which he lives, while his use of beasts of burden and of tools give him a power and a radius of action quite unique.

Second, we have the mammals, formerly predominant but now scarcely a serious factor except for those few, like rats and mice and the domesticated animals, that live as man's associates. Mammals, excepting for a very few that live within the tropics, have an outer coat of hair or a covering of fat which insulates them from the changes in the temperature of the air or water. Their body temperature is high and is maintained at a constant level, except in the hibernating types like some bears and mice and squirrels which become torpid in cold weather, and in the egg-laying types. Mammals are all large, and some are very large. They are all active, and all show great ability to travel.

Third, we have the birds, now, like the mammals, much less numerous than they used to be. All birds have feathers which, like the hair of mammals and the clothes of man, serve to hold an insulat-

[1] The illustrations are through the courtesy of the Bureau of Entomology, Department of Agriculture.

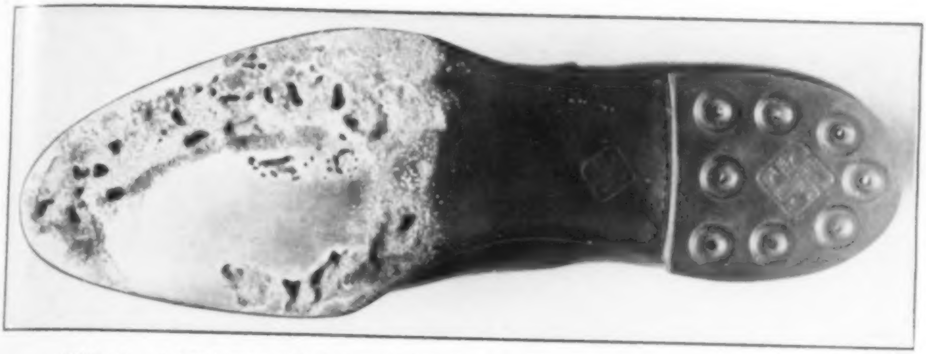


FIG. 1. DAMAGE DONE BY WHITE ANTS OR TERMITES TO A SHOE
STORED ON INFESTED WOODWORK IN A BUILDING ON FIFTH AVENUE, NEW YORK

ing layer of air between their heated bodies and the air through which they move. The body temperatures of birds are high, and like those of mammals are maintained at a constant level. There are no birds that hibernate as some mammals do. The power of flight gives birds (and bats) a very great advantage in getting from place to place. But this advantage is offset by the necessary lightness of their structure as a whole and the uselessness, except for flight, of the first pair of limbs. The flightless birds are of three different types. The penguins and the flightless auks have their wings modified into effective fins by means of which they swim. The flightless cormorants, like the other cormorants, swim almost wholly with their feet, as did the flightless water birds of the Cretaceous seas. The flightless land birds, whether rails, pigeons, kiwis or ostrich-like types, have powerful legs and small and useless wings.

Fourth, we have the insects. The body temperature of insects is not appreciably different from that of their surroundings. But insects can adapt

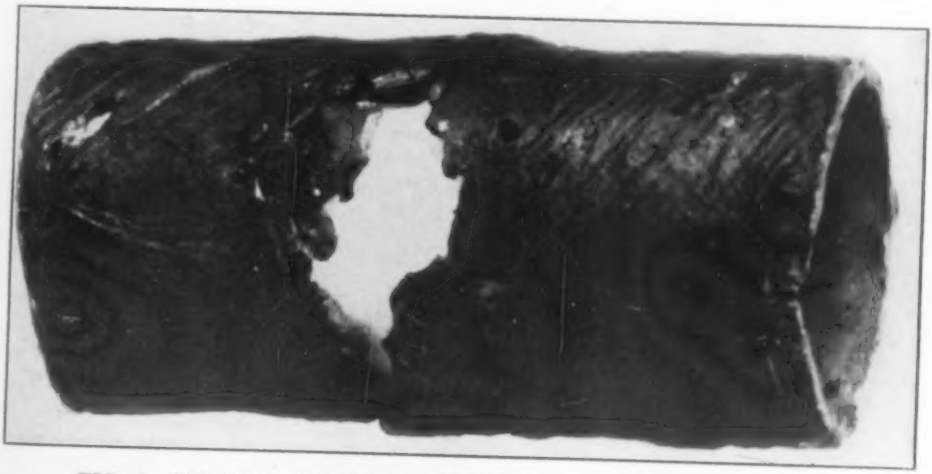


FIG. 2. TYPICAL TERMITE INJURY TO LEAD SHEATHED CABLE
THIS TYPE OF DESTRUCTION OCCURS THROUGHOUT THE WARMER REGIONS OF THE WORLD, INCLUDING THE SOUTHERN UNITED STATES.

FIG. 3. PAPER DESTROYED BY TERMITES
THIS PAPER WAS STORED IN AN INFESTED BUILDING IN BALTIMORE, MD.

themselves to changing temperatures quite as well as mammals or as birds, though in a different way. They simply become inert and torpid, some if it gets too hot, others if it gets too cold, and not a few at both extremes. Nearly all of them are when adults, and mostly all their lives, protected from a loss of moisture by a tough impervious covering. Most insects when adult can fly, and many can cover enormous distances. The insects are all small, but this very fact gives them a great advantage not possessed by the mammals, birds or man. I am informed by Mr. René Bache that an average man is the equivalent in weight of 3,760,000 house-flies. This means that the ability of the common house-fly to survive under adverse conditions is 3,760,000 times as great as that of man.

This leads to interesting speculation as to what is to be the future of the world.

The mammals have ceased to dominate the earth. The large formidable vegetarian types, as has been explained, have given way to man. There seems to be no chance of their return.

Birds, though efficient in their way, were never serious competitors of the reptiles, or the mammals, or of man. Birds have persisted through their ability to escape from danger, not to overcome it, or to dominate the other creatures that live with them.

This leaves the insects as the chief competitors of man. In many ways

their activities run quite parallel to his. Strange as it may seem, the activities of the insects are more like those of man than the activities of either are like those of birds and mammals.

Some insects keep others as domestic animals, and in a few cases the latter would have disappeared but for the care taken of them by their masters. Thus the ants carefully care for and protect various kinds of aphids, jassids and membracids, as well as the caterpillars of certain lycænid butterflies for the sake of the honey-like secretions they produce. Their relation to these various insects is much like ours to cows. Usually the ants merely attend these as they feed upon the plants, but sometimes they build elaborate structures over them, like stables. Some of the aphids they carry to safety under ground in winter, and some of the caterpillars they herd in their own nests in the daytime, driving them out at night to feed and home again at dawn, treating them therefore much as we do cows. Indeed, certain ants of southern Asia and of Africa force some kinds of caterpillars to make the transformation into pupæ within their own nests deep underground, thus carefully protecting them from the time they leave the egg until they become butterflies and fly away.

Some insects have learned the use of tools, like the spinning ants, which use their own grubs in much the same way that we do thread and needle, and those caterpillar wasps that use a little pebble or a stick to smooth the earth down over a buried caterpillar.

A few insects use narcotics to render their victims helpless much in the same manner as do certain individuals of our own kind. For instance, there is a curious bug in Java which feeds on ants. When an ant approaches it rises up, exposing some long hairs on the under side which are wet with a secretion from some special glands. The ant greedily licks off this substance, which, however, is intoxicating. When the ant has had enough to make it "groggy" the bug

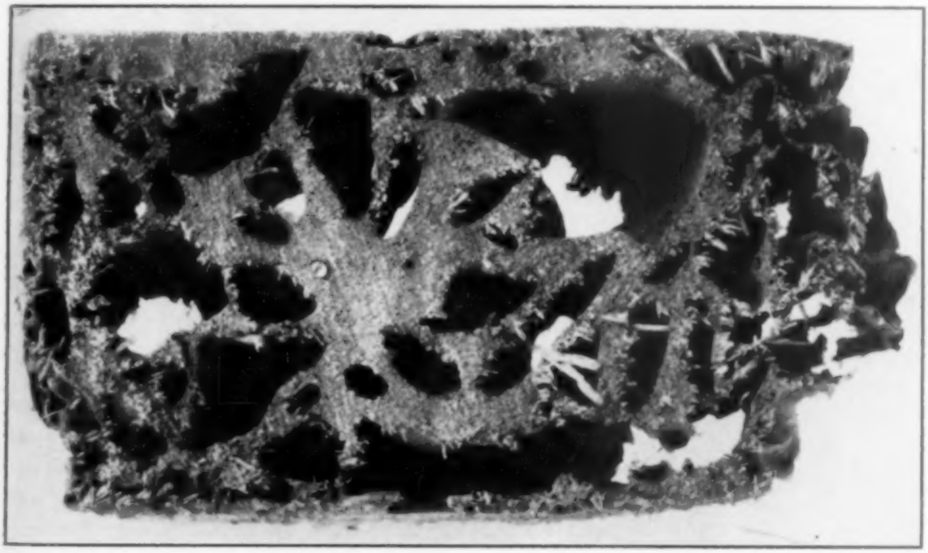


FIG. 4. A TIMBER DESTROYED BY TERMITES
FROM A BUILDING IN THE SOUTHERN UNITED STATES.

FIG. 5. THREE EARS OF FLINT CORN ATTACKED BY THE EUROPEAN CORN-BORER.

with its sharp beak stabs it suddenly through the neck and sucks its juices out.

Many ants practice an elaborate form of agriculture, growing certain types of fungi with as much skill as we show in growing our own crops.

The paper and the other kinds of nests of wasps, and the wax, mud and other cells of wasps and bees show an ability to use a wide range of materials, some of which are not found in nature but are produced by them themselves by chemical alteration of substances they gather.

The pitfalls of ant-lions and the snares of the grubs of fungus-gnats and spiders are most extraordinary structures. The spiders, especially in the construction of their numerous types of webs, of their varied types of burrows, sometimes with a strong hinged lid, and of their turrets, as well as in their flight, show an engineering knowledge which in its way is quite exhaustive.

In two entirely different groups of in-

sects, the neuropteroid termites and the hymenopterous ants, bees and wasps, there are found most complicated social systems, superficially much like, though fundamentally wholly different from the human.

Very many insects of a multitude of different kinds have learned to clothe themselves. Large numbers, as for instance caddis worms and clothes moths, do this for protection in their larval stages. But many more when entering the pupal stage spin a cocoon of silk or of a felt of silk and hair or of a mixture of silk and other substances which is sometimes waterproofed to guard against the loss of moisture.

Many insects, among the solitary as well as among the social kinds, have a very definite conception of private property and their rights thereto.

One commonly hears it said that among the insects all these attributes are matters of instinct, which is quite inflexible, and not of reason, and therefore that an insect can not change its habits. But this is not quite true. Many insects have the ability to change both form and habits if faced with new conditions.

Among the birds we find only the bowers of the bower-birds, ornamented nests of various sorts, the communal nests of certain weaver-birds and parrots, the complicated nests of other weaver-birds and "hang-nests," the glutinous nests of certain swifts, and a few other types of nests to offset the multitudes of far more elaborate structures built by the insects. Among the mammals we find little of a comparable nature, and what there is is almost entirely confined to rodents, such as the beaver, musk-rat, trader-rat, etc.

In the distant prehistoric past man made use of various mammals which he

FIG. 6. ORCHARD TREES WHICH HAVE BEEN KILLED BY THE SAN JOSE SCALE.

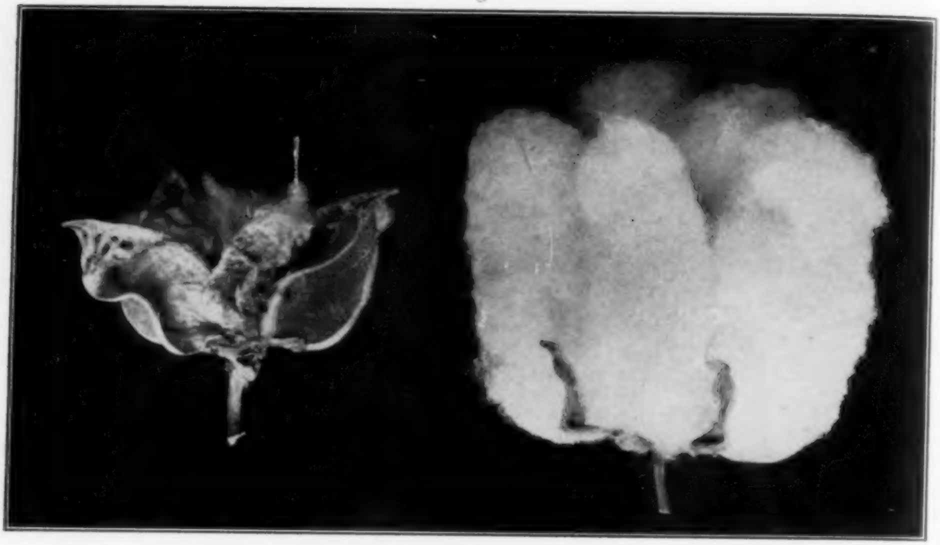


FIG. 7. THE COTTON BOLL
THE BOLL ON THE RIGHT IS NORMAL; THAT ON THE LEFT HAS BEEN ATTACKED BY THE PINK BOLL-WORM.

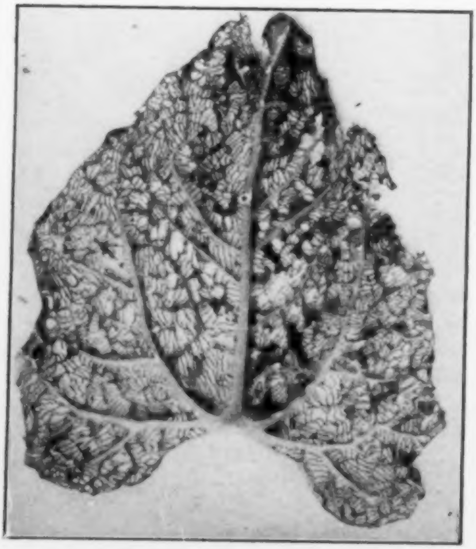


FIG. 8. A BEAN LEAF
WHICH HAS BEEN SKELETONIZED BY THE MEXICAN BEAN BEETLE.

domesticated to overcome the others. He did this, however, with no definite purpose and with no definite idea of what the result would be. At the present time the insects are making similar use of man. The recent vast improvement in the means of transportation, by steamer, train and automobile, is being utilized extensively by insects. By this means they get from place to place and from one country to another, passing easily over barriers hitherto insuperable for them. Also the vast improvement in our agricultural methods whereby large areas are planted with a single crop facilitates the increase of destructive forms.

As matters stand to-day, mankind exists in his present state by virtue of the fact that he has displaced the large grass-feeding mammals and thereby is enabled to practice agriculture on a

colossal scale. But the limit of expansion on this basis soon will be reached.

We now are in the midst of the mechanical phase of the Age of Man, and we have no serious competitors except the insects. By an uncomfortable coincidence, much that we do to help ourselves also helps the insects.

Not many generations hence we shall have reached the saturation point along the present lines. Our future expansion then will depend on our ability to offset the increase in the human population of the world by the displacement of its equivalent in insects.

What will the future bring? Will man continue still to hold his own, or will the Age of Man be followed by the Age of Insects?

FISHES THAT LIVE IN THE MOUTHS OR GILL CAVITIES OF OTHER FISHES[1]

By E. W. GUDGER

ASSOCIATE IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

It is a fact well known to ichthyologists that the hagfishes, *Myxine* and *Bdellostoma*, and various lamprey eels, all members of the class Cyclostomata or round-mouthed fishes, have parasitic habits. Indeed, the American Museum has an exhibit, designed and the installation supervised by Dr. Bashford Dean, showing a river lamprey (*Lampetra fluviatilis*) parasitic on a catfish. Sucking fast to its host, this parasite by means of the teeth set inside the circular rim of its mouth, frets away and eats the flesh of its host and drinks its blood. On the other hand, the hagfishes or slime eels, bore their way into the bodies of their hosts, devour the flesh and internal organs, often leaving nothing but "skin and bones."

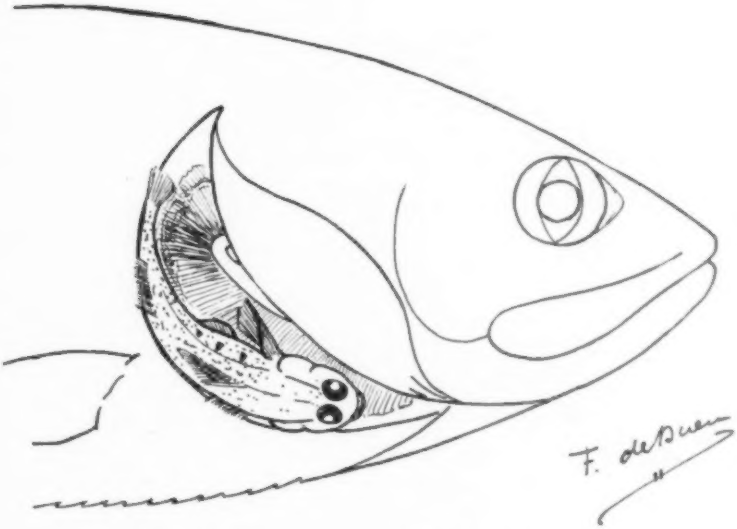
Still less well known is the fact that a little catfish in South America, bearing the significant name of *Stegophilus insidiosus* (the "insidious cover-lover") lives in the gill cavities of his huge kinsman *Platystoma*. At first it was thought that the little siluroids were the young of the big catfish carried in his mouth until hatched and able to care for themselves (a very extensive practice among these fishes). Then it was presumed that they were messmates of their kinsman, living on small organisms drawn into his mouth in his respiration. But now they are known to be parasites living among the gills of their host and rasping with their sharp teeth and spines through the soft tissues of the gills and drinking his blood. Other fishes of the same group are known to practice the same habits.

These are cases of true parasitism—the fish lives on the flesh and blood of its host—while the cases now to be considered are cases of commensalism, where the two fishes feed at the same table, or of symbiosis, where the two fishes merely live together—the weaker for protection by the stronger. The most widespread but relatively little known case of this latter phenomenon, until the publication of my recent article in *Natural History*, is the habit of various members of the family Echeneididæ, the sucking fishes, of entering the mouths and gill cavities of sharks and rays and of large bony fishes like the swordfish (*Histiophorus*), the sailfish (*Tetrapturus*), the sunfish (*Mola*) and others. This paper aroused considerable interest and various accounts of this habit and several actual specimens of the little fishes have since come in to me. This is a case of commensalism, where the two fishes live in amity—the smaller gaining protection and possibly feeding on the scraps let fall by its protector.

Now, however, we have the still more remarkable case of bony fishes other than Echeneids (sucking fishes) living as commensals or symbionts in the mouth cavities of other Teleostean fishes. The sucking fishes are more or less dependents, but the fishes now to be considered are apparently free-livers. How they gather food is not very clear, but all the known facts follow.

The principal account is from the ob-

[1] Gudger, E. W. "An Odd Place of Refuge: The Habit of the Shark Sucker, *Echeneis* or *Remora*, of taking Refuge in the Gill Chamber or Mouth Cavity of its Host." *Natural History*, 1922, 22, pp. 243–249, fig.



servations of Dr. Fernando de Buen, chief of the section of biology in the Instituto Español de Oceanografia, Madrid. In checking up recently the bulletin of the Spanish natural history society for titles for our continuation classified card catalogue of ichthyological literature, I chanced upon his interesting illustrated article quoted below. When I wrote Dr. de Buen asking permission to utilize his data and reproduce his figure, he courteously gave permission for the use of the one and sent the original of the other. His account reads as follows:[2]

While studying the Clupeidæ that Professor Lozano possesses in his laboratory at the Madrid Museum, I had the good fortune to find one of them lodging a small *Gobius* in the gill cavity. The specimen was captured at Melilla (Aug., 1912) during the expedition directed by my father in the north of Africa.

From the position in which it was found and for other reasons which are given later I can not believe that the *Gobius* caught in the nets and mixed with a profusion of *Alosa* will introduce itself into the gill chamber of one of these fishes casually. The species identified as *Gobius pictus* Malm has never been cited off the coasts of Spain nor in Northern Africa, but lives in the depths of the Northern European seas, and one may believe with more foundation that it was transported to the south during the migrations of the Clupeidæ. Moreover, the *Gobius* presents very clear phenomena of adaptation; the first and second dorsals have the first spine growing on the back and this is prevented from being raised by a membrane which fastens it and runs on the same side outside of the median line; this adaptation proves to us that the *Gobius* has been carried for a long time in the gill chamber of the *Alosa*. On the other hand, commensalism between fishes is very rare; but I know of an analogous case (Van Beneden, 1883) where Risso says that he observed at Nice a species of the family Murænidæ lodging in the gill cavity of a *Lophius piscatorius* L. The *Gobius*, on account of its small size and the power of using the ventral fins as a sucker (*Gobius pictus* has this highly developed), possesses qualities very favorable to commensal life.

From the outside of the *Alosa* nothing abnormal is seen; the gill flap is perfectly adapted and completely hides the fish which it covers. Lifting the flap, the *Gobius* is seen resting on the shoulder girdle; its head is placed in the broadest part, and its body extends upwards, making place for itself at the end of the gills. The body of the *Gobius* is compressed and sloping, a transverse section giving approximately a rhomboid figure.

[2] Buen, Fernando de, "Sobre la Presencia y Caracterización de un *Gobius* de los Mares del Norte Comensal de una *Alosa vulgaris* Cuv. Val." Boletin Real Sociedad Española Historia Natural. Madrid, 1916, Vol. 16, pp. 146–147, fig.

Apart from the modifications that we see in the dorsal, the other fins adapt themselves to the surfaces that surround them. The ventral, perfectly extended, appears to be adhering to the gills of the *Alosa*. One of the pectorals rests on the shoulder girdle and is folded outside; the other pectoral is folded simply that it may not come in contact with the gill flap. The anal inclined outwards rests on the shoulder girdle.

De Buen positively identifies his specimen as *Gobius pictus* of Smitt's "Scandinavian Fishes" (1892). The length of the *Alosa*, the host fish, to the base of the caudal fin was 213 mm (about 8.5 inches); of the *Gobius*, 36.5 mm (about 1.5 inches).

Señor de Buen's citation from Van Beneden is correct, since the latter does cite Risso. Careful examination of Risso's work on the fishes of the gulf of Nice[3] shows Van Beneden in turn to have been correct in his citation. On page 171 Risso in speaking of the "baudroies de la Méditerranée" says: ". . . le sac de leurs ouïes sert quelquefois de repaire à la apterichte oculé" ("the sac of the gills serves sometimes for a haunt or hiding place for *Apterichtus oculatus*"). This name is apparently a synonym for the Murænoid fish *Sphagebranchus oculatus* of Risso, but under this latter fish Risso does not refer to such a habit. However, referring to *Sphagebranchus bimaculatus*, he says (p. 196): "One often encounters it in the cavity of the branchial orifice of the great rays." This in turn apparently refers to the giant rays of the genus *Cephaloptera* (Manta), but reference to Risso's account of these rays reveals nothing.

It is greatly to be regretted that Risso does not give us more details concerning these interesting habits and adaptations. It is not difficult to understand how fishes like *Echeneis* or *Gobius*, which have adhesive disks made of transformed fins, by holding fast can avoid being swept into the stomachs of their hosts, but how eels can become mouth and gill symbionts and avoid that fate is not so easy to realize. However, as my old teacher, Professor W. K. Brooks, used to say, "It is not safe to say that a thing does not exist merely because we have never seen it."

[3] Risso, A., "Histoire Naturelle des Poissons de la Méditerranée qui Fréquentent les Côtes des Alpes Maritimes et qui Vivent dans le Golfe de Nice" (In his "Histoire Naturelle . . . de l'Europe Méridionale," etc. Paris, 1826, pp. 171 and 196).

THOMAS MOFFETT, ELIZABETHAN PHYSICIAN AND ENTOMOLOGIST

By HARRY B. WEISS

NEW BRUNSWICK, NEW JERSEY

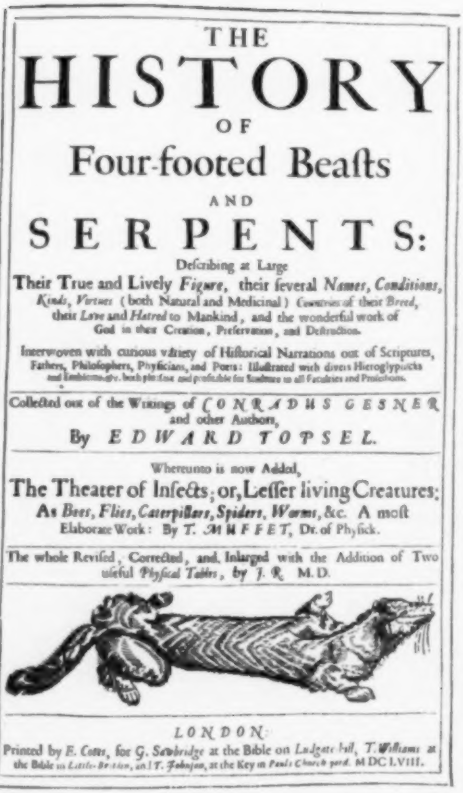
WHILE clever, sagacious, vain, kaleidoscopic Queen Elizabeth, who was alternately rough, blasphemous and hard, and silly, flattery-loving and ostentatious, and whose "endocrine balance" may have been abnormal, as MacLaurin suggests, was juggling suitors and giving England a stable government, there lived and flourished "a notable ornament to the company of Physicians, a man of the more polite and solid learning, and well experienced in most Sciences," named Thomas Moffett.

Of Scottish descent, born in 1553, in all likelihood in the parish of St. Leonard's, Shoreditch, Moffett's life paralleled the reign of Elizabeth. His father, Thomas Moffett, was a haberdasher of London, and his mother was Alice Ashley, of Kent.

For his early education Thomas was sent to one of the few good schools that existed during Elizabethan times, the Merchant Taylors' School, of which Richard Mulcaster, a notable schoolman, was headmaster for twenty-five years. Here his studies undoubtedly included drawing and music, of which Mulcaster was a strong advocate. After five years in this school, he matriculated in May, 1569, as a pensioner of Trinity College, Cambridge. He was then sixteen years old, and this was about the usual age prescribed by the university regulations for entering college. Seven years were necessary for the degree of master of arts, and one could then proceed to degrees in theology, medicine and law. However, by the payment of money or upon suitable approval from the right persons, noblemen and influential students frequently got their masters' degrees in less time.

In October, 1572, he went to Caius College, where he graduated B.A. While pursuing the classics he also studied medicine under Thomas Lorkin and John Caius, both physicians of note, and hobnobbed with Timothy Bright, Thomas Penny and Peter Turner. Timothy Bright later became quite distinguished as a physician, but is probably remembered now if at all in connection with his invention of modern shorthand, as set forth in his work: "Characterie. An Arte of shorte, swifte, and secret writing by character. Inuented by Timothe Bright. Doctor of Physicke." (London 1588.) Thomas Penny, in addition to being a physician, was also a botanist and entomologist and assisted Conrad Gesner, the Swiss naturalist, physician and voluminous writer on various subjects, famous for his "Historia Animalium," in which he intended to describe every known animal.

Moffett, deciding to graduate M.A., from Trinity College in 1576, was expelled from Caius by Thomas Legge, the master who later, about 1581, was apparently committed to the fleet because of his disdainful treatment of certain letters from the queen, relating probably to his support of north-country Romanists in his college. The fellows made this a charge against him, supplementing it with having expelled Moffett without their consent, with having misappropri-



THE
HISTORY
OF
Four-footed Beasts
AND
SERPENTS:
Describing at Large
Their True and Lively *Figure*, their several *Names*, *Conditions*, *Kinds*, *Virtues* (both Natural and Medicinal) Countries of their *Breed*, their *Love* and *Hatred* to Mankind, and the wonderful work of God in their Creation, Preservation, and Destruction.

Interwoven with curious variety of Historical Narrations out of Scriptures, Fathers, Philosophers, Physicians, and Poets: Illustrated with divers Hieroglyphicks and Emblems, &c. both pleasant and profitable for Students in all Faculties and Professions.

Collected out of the Writings of *CONRADUS GESNER* and other Authors,
By *EDWARD TOPSEL.*

Whereunto is now Added,
The Theater of Insects; or, Lesser living Creatures:
As *Bees*, *Flies*, *Caterpillars*, *Spiders*, *Worms*, &c. A most Elaborate Work: By *T. MUFFET*, Dr. of Physick.

The whole Revised, Corrected, and Inlarged with the Addition of Two useful *Physical Tables*, by *J. R.* M.D.

LONDON:
Printed by *E. Cotes*, for *G. Sawbridge* at the Bible on *Ludgate hill*, *T. Williams* at the Bible in *Little-Britain*, and *T. Johnson*, at the Key in *Pauls Church-yard*. MDCLVIII.

TITLE PAGE OF TOPSEL'S "HISTORY OF FOUR-FOOTED BEASTS AND SERPENTS" TO WHICH MOFFETT'S "THEATER OF INSECTS" WAS APPENDED

ated college funds and with "continuall and expressive loud singinge and noyse of organs," which disturbed the students. All of which charges were settled.

Upon leaving Cambridge, Moffett traveled abroad. At Basle he attended the lectures of Theodore Zwinger and Felix Plater, both physicians, and in 1578 received the degree of M.D. and published two collections of his medical theses. The next year he visited Italy and Spain, where he studied silkworm culture and various insect activities. Twenty years later he published some of his observations in the form of a poem entitled: "The Silkwormes and their Flies; Lively described in verse, by T. M. a Countrie Farmar, and an Apprentice in Physicke. For the great benefit and enriching of England," (London 1599). In July, 1580, he was at Nuremberg, and often at Frankfort between October, 1580, and the spring of 1582. He married in London, at St. Mary Cole Church, Jane Wheeler, by a license dated December 23, 1580. In 1582 he returned to Cambridge and was incorporated M.D. In July, 1582, he visited Elsinore with Peregrine Bertie, Lord Willoughby, who clothed King Frederick, of Denmark, with the Order of the Garter. While there he attended court dinners that lasted seven and eight hours and met Peter Severinus and Tycho Brahe, the latter being the distinguished Danish astronomer, who, having lost part of his nose in a duel, replaced the missing tissue with gold, so cunningly colored and fitted that few could detect it, and who incurred the disgust of his fellow nobles by marrying a peasant girl, this being even more disgraceful than studying astronomy.

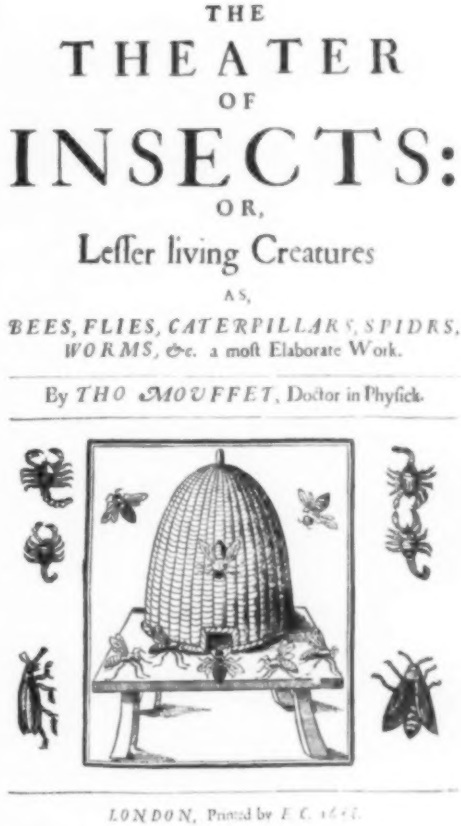
Moffett apparently liked to travel, in spite of the inconveniences and perils of the time. In England, little traveling was done for pleasure. Roads as we know them did not exist. They just happened, and moreover were infested by highwaymen, tramps, tinkers, jugglers, vagrants and beggars with filthy rags and running sores manufactured by the application of arsenic, unslaked lime or other corrosives. Linen was snitched from hedges, and other forms of thievery flourished even as they do now. Inns were numerous, but many of the servants were thievish.

At Frankfort in 1584, he published an elaborate commentary of his medical views written in a style similar to that of Erasmus's "Colloquia." The title is "De Jure et Præstantia Chemicorum Medicamentorum." With this he printed four letters addressed to Phila-

lethes Germanus and one to Endymion Luddipolensis, the five being dated from London between February and April, 1584. The work received some notice abroad and attention in Zetner's "Theatrum Chemicum" published at Strassburg in 1613. All Moffett's medical books appear to have been published at Frankfort, then the center of the book trade in Germany and seat of the semiannual book fair to which publishers took their samples.

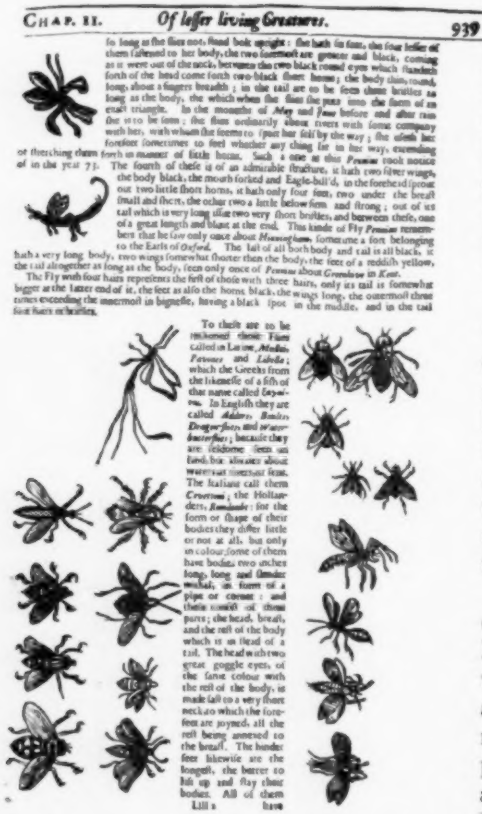
While in Europe, Moffett became infected with the Paracelsian doctrine of medicine, and when he established himself in England he and John Hester, translator of medical books and distiller, or, as he styled himself, "practitioner in the Spagericall Arte," at Paul's Wharf, became the chief exponents and defenders of the Paracelsian system.

During the beginning of the sixteenth century, the Galenists, with their complex and polypharmous vegetable prescriptions, were the most progressive branch of the medical profession and with the followers of Hippocrates, master of detail and founder of medicine as a science, they had no serious disagreement. From the ranks of the Galenists sprang the Chymists, with their empirical practices and additions to the materia medica and pharmacopeia, which sect flourished during the latter part of the century. Philippus Aureolus Theophrastus Bombastes von Hohenheim or Paracelsus, whose system attracted Moffett, was a widely traveled German physician and chemist, whose real or imitation cures and large practice attracted patients of quality from all parts of Europe. Insolent, inflated and bellicose, he publicly burned Galen's works at Basle and disregarded custom by lecturing in German instead of Latin. He contributed opium, mercury, sulphur, salt arsenic, iron, etc., to materia medica, was killed by being thrown out of a window by a colleague during a heated argument, and is generally characterized as the "greatest charlatan and mountebank that ever acquired celebrity in the profession."


THE
THEATER
OF
INSECTS:
OR,
Leſſer living Creatures
AS,
BEES, FLIES, CATERPILLARS, SPIDRS, WORMS, &c. a moſt Elaborate Work.
By THO MOUFFET, Doctor in Phyſick.
LONDON, Printed by E. C. [illegible]

TITLE PAGE OF MOFFETT'S "THEATER OF INSECTS"

Moffett apparently was not completely won over to the Paracelsian system, for in 1588 he published again in Frankfort a digest of Hippocrates entitled, "Nosomantica Hippocratea sive Hippocratis Prognostica cuncta ex omnibus ipsius scriptis methodice digesta." By this time he had secured a good practice, first in Ipswich and later in London. He was admitted as a candidate of the College of Physicians on December 22, 1585, and as a fellow and censor in 1588.



CHAP. II. *Of leſſer living Creatures.* 939

ſo long as ſhe flies not, ſtand bolt upright: ſhe hath ſix feet, the four leſſer of them faſtened to her body, the two foremoſt are greater and black, coming as it were out of the neck, between the two black round eyes which ſtandeth forth of the head come forth two black ſhort horns; the body thin, round, long, about a fingers breadth; in the tail are to be ſeen three briſtles as long as the body, the which when ſhe flies ſhe puts into the form of an exact triangle. In the moneths of *May* and *June* before and after rain ſhe is to be ſeen; ſhe flies ordinarily about rivers with ſome company with her, with whom ſhe ſeems to ſport her ſelf by the way; ſhe uſeth her forefeet ſometimes to feel whether any thing lie in her way, extending or ſtretching them forth in manner of little horns. Such a one as this *Pennius* took notice of in the year 73. The fourth of theſe is of an admirable ſtructure, it hath two ſilver wings, the body black, the mouth forked and Eagle-bill'd, in the forehead ſprout out two little ſhort horns, it hath only four feet, two under the breaſt ſmall and ſhort, the other two a little below ſtem and ſtrong; out of its tail which is very long iſſue two very ſhort briſtles, and between theſe, one of a great length and blunt at the end. This kinde of Fly *Pennius* remembers that he ſaw only once about *Hunningham*, ſometime a fort belonging to the Earls of *Oxford*. The laſt of all both body and tail is all black, it hath a very long body, two wings ſomewhat ſhorter then the body, the feet of a reddiſh yellow, the tail altogether as long as the body, ſeen only once of *Pennius* about *Greenhow* in *Kent*.

The Fly with four hairs repreſents the firſt of thoſe with three hairs, only its tail is ſomewhat bigger at the latter end of it, the feet as alſo the horns black, the wings long, the outermoſt three times exceeding the innermoſt in bigneſſe, having a black ſpot in the middle, and in the tail four hairs or briſtles.

To theſe are to be reckoned theſe Flies called in Latine, *Muſcæ, Pavones* and *Libellæ*; which the Greeks from the likeneſſe of a fiſh of that name called *Σκολό-πενδρα*. In Engliſh they are called *Adders, Bolts, Dragonflies* and *Water-butterflies*; becauſe they are ſeldome ſeen on land, but alwaies about waters as rivers, or ſeas. The Italians call them *Cavettoni*; the Hollanders, *Ronbouts*: for the form or ſhape of their bodies they differ little or not at all, but only in colour; ſome of them have bodies two inches long, long and ſlender withal, in form of a pipe or cornet: and theſe conſiſt of three parts; the head, breaſt, and the reſt of the body which is in ſtead of a tail. The head with two great goggle eyes, of the ſame colour with the reſt of the body, is made faſt to a very ſhort neck, to which the fore-feet are joyned, all the reſt being annexed to the breaſt. The hinder feet likewiſe are the longeſt, the better to lift up and ſtay their bodies. All of them

Llll 2 have

A PAGE OF MOFFETT'S BOOK, DEVOTED TO "FLIES"

London at this time was for the most part a network of badly paved lanes made tenebrous by the overhanging fronts of houses and malodorous by the householders, who deposited their garbage and refuse in the gutters. Mud and filth prevailed in many streets. Coaches and carts rattled by, regardless of whom they splashed after a rain, and often blocked the streets, while their riders shopped and haggled over prices. Dekker wrote:

> In every street, carts and Coaches make such a thundring as if the world ranne vpon wheeles; at evrie corner, men, women, and children meete in such shoales, that posts are sette up of purpose to strengthen the houses, least with iustling one another they should shoulder them downe. Besides, hammers are beating in one place, Tubs hooping in another, Pots clincking in a third, water-tankards running at tilt in a fourth; heere are Porters sweating vnder burdens, there Marchants-men bearing bags of money, Chapmen (as if they were at Leape-frog) skippe out of one shop into another; Tradesmen (as if they were dancing Galliards) are lusty at legges and never stand still; all are as busie as countrie Atturneyes at an Assises.

The main thoroughfare was the Thames, which every one used in preference to the narrow, dirty streets. Ferries ran to and from various points, and all kinds of craft sailed the river. And there was London Bridge with its houses and shops and covered way, and the tower guarding the middle draw ornamented by poles on which were stuck the rotting heads of traitors.

Some of Moffett's patients were quite distinguished. In 1590 he attended Sir Francis Walsingham, fanatical Puritan who looked after Elizabeth's designs against the Jesuits and was one of her most capable statesmen. Early in his practice he attended Lady Penruddock and Sir Thomas and Edmund Knyvet. In July, 1586, Drs. Penny and Moffett attended Anne Seymour, duchess of Somerset, and attested her will. In 1591 he was appointed physician to the forces operating in Normandy under the Earl of Essex. After his return to London he frequently attended court and was patronized by Henry Herbert, second earl of Pembroke. Mary Herbert, the earl's wife, patroness of men of letters and poets, captivated by his culture, persuaded him to live in Wiltshire at her home. The earl gave him the near-by manor-house of Bulbridge for a residence, and the latter part of his life was spent at or near Wilton, as the earl's pensioner. As a result of the earl's influence he was also elected M.P., for Wilton in 1597. While at court he became acquainted with Sir Francis Drake, chief

naval worthy of the time, whose piratical enterprises against the colonies of Spain won the approval of Elizabeth.

Moffett's wife died while they were living at Wilton and was buried there on April 18, 1600. He married again a widow named Catherine Brown, but did not live long, dying June 5, 1604. He was buried in Wilton Church. Moffett's second wife survived him, and to her four children by her first husband Moffett, in addition to other bequests, willed his musical instruments, including a pair of virginals. Moffett's own daughter Patience is mentioned in the will, and his brothers William and Thomas were made overseers. When Moffett's widow died in 1626 she left to Patience a portrait of Moffett and a book "in his writing."

Moffett was the author of two posthumous works. In 1590 he had finished a book on the natural history of insects, which represented in part compilations from the works of Edward Wotton and Conrad Gesner and from papers left to him by Thomas Penny, botanist, entomologist, friend of Gesner and prebendary of St. Paul's. Moffett, in the preface of his book, speaks of his indebtedness to these and other persons, including Peter Turner, whose letters came also into Moffett's possession. The plates for the illustrations appear to have been Turner's. Moffett was alternately encouraged and discouraged as he wrote his "history." His friends deterred him for a while because they thought insects insignificant and Moffett wasting his time by shaping the work of others. He persisted, however, in going ahead, adding more than 150 illustrations unknown to Gesner and Penny, correcting the language and omitting more than a thousand "tautologies, trivial matters and things unseasonably spoken," because, as he said, of "the squemish stomachs of men of this nauseating age."

CHAP. 21. *Of lesser living Creatures.* 1009

Joach. Camerarius did elegantly express, when he sent to *Pennius* the shape of this Insect out of the storehouse of natural things of the Duke of Saxony, with these Verses:

A Hee begat me not, nor yet did I proceed
From any Female, but my self I breed.

For it dies once in a year, and from its own corruption, like a Phœnix, it lives again (as *Mamona* wrote) by heat of the Sun.

A thousand summers heat and winters cold
When she hath felt, and that she doth grow old,
Her life that seems a burden, in a tomb
Of spices laid, comes younger in her room.

The second kinde of Nose-horn very rare and worthy to be seen, sacred to Mercury, *Carolus Clusius* sent painted from *Vienna*, where it is very frequent, the form is as you see it: it would seem all pitch colour, but that the belly is a full red; that crooked horn in the nose is so sharp, that (what is said of an Elephant going to battle) you would think it had got an edge by rubbing it against a rock. The third Nose-horn, and fourth seem to be alike, but that the former hath wings growing out longer than the sheath covers, but the others are shorter. You would say they were rub'd with shining ink, they are so perfectly all over black. The Ram or [illegible], hath knotty horns, violet colour, a head greenish from gold colour, the shoulders like vermilion, a purple coloured belly, sheath wings of the colour of the head, it goes forward with legs and feet, of a light red, but the wings that up in the sheath, do fitly express the small whitish membrane of a Cane.

The greater Beetles without horns are many; namely, that is called *Pilularius*, and another that is called *Melolonthes*; another purple, one again that is dark coloured, one called *Arboreus* and another *Fullo*. Some call the *Pilularius* the dunghill Beetle, because it breeds from dung and filth, and also willingly dwels there. The Greeks call it [illegible], and [illegible], and from its form like a cat, [illegible]; the Germans, *Roßkafer*, *Kaat*, or *Mistkafer*; in English, *Dung-beetle*, *Sharnbugg*; in French, *Fouille merde*, as you would say *Dung-digger*; the Latines call it *Pilularius*, because it turns up round pills from the dung, which it fashions by turning it backwards with its hinder feet. *Porphyrius* doth thus describe the nature of it: All your *Pilulari* have no females, but have their generation from the Sun; they make great balls with their hinder feet, and drive them the contrary way, like the Sun it observes a circuit of 28. daies. *Ælian* saith almost the same. There is no female Beetle, it puts the seed into a round ball of dung, which it rowls and heats in 28. daies, and so produceth its young. They would say

R r r r that

A PAGE OF MOFFETT'S BOOK, DEVOTED TO "BEETLES"

After its completion, he obtained permission for its publication at the Hague on May 24, 1590, and dedicated it to the queen. Delays followed, however, and after the queen's death it was rededicated to James I. After Moffett's death the manuscript found its way to the hands of Darnell, Moffett's apothecary, who sold it to Sir Theodore Mayerne. Mayerne was a French physician who defended the use of chemical remedies. He became unpopular in France and went to London in 1611, where he established a large practice. Mayerne kept the manuscript for some years, due to the high cost of printing, and finally published it in London in 1634 with a

dedication to Sir William Paddy, another London physician, the title of the folio being, "Insectorum sive Minimorum Animalium Theatrum . . . ad vivum expressis Iconibus super quingentis illustratum." In 1658 it appeared in English, under the title "The Theater of Insects, or lesser living Creatures," having been translated by John Rowland, M.D., and appended with plates to Topsel's "History of Four-footed Beasts and Serpents," "The whole Revised, Corrected, and Inlarged with the Addition of Two useful Physical Tables, by J. R. M. D."

Moffett's *magnum opus*, said to be the first zoological work printed in Britain, is divided into two books, the first consisting of twenty-nine chapters and the second of forty-two. Seven chapters of Book I are devoted to bees, and the remaining ones to various insects. The titles now appear quaint, as shown by the following examples: X, of "Flyes," XVII, grasshoppers and "krickets," XVIII "of moths called Blattae," XXIX, of the "wall-louse or winged Punie." Book II is about insects without wings, caterpillars, especially silk spinners, and other creatures. Some of the chapter headings are: VI, of the "whurlworm," VII, "of a caterpillar called Staphylinus," IX, "of Chisleps or pill bugs," XIII, "tame or house spider," XXII, "six footed worms in living creatures and of lice in men." Short chapters deal with such miscellaneous creatures as "horseleeches," water worms, sheep lice, mites, clothes moths, fleas and water insects. The "physical index" added by Roland refers to the pages of the book whereon are listed remedies for various diseases of man.

Some of the accounts are quite lengthy and show much diligence and knowledge of the writings of ancient authors, whose beliefs and mistakes were repeated by Moffett. Quotations are numerous, and the names of Aristotle, Pliny, Cardan, Galen, Marcellus, Bellonius, Lonicerus, Cordus, Altius, Homer, Plato, Gesner, Democritus, Varro, Pindar, Socrates, Africanus, Scaliger, Suetonius, Plutarch, Aristophanes, etc., appear frequently. Apparently few original assertions are included. In some places Moffett includes the results of his own observations during his travels or about London, and speaks of receiving specimens of "Cerambyces" from Quickelbergius, of Antwerp, and of giving specimens to Dr. Penny. In general, Moffett's treatment of each species gives the name of the insect in Hebrew, Italian, French, etc., the opinions of the Greeks concerning it, a rough description interspersed with remarks by Pliny, Socrates, etc., a statement about the structure, breeding habits and food plants of the species according to various authors and travelers, and then an account of the myths surrounding the insect and its uses in medicine. His treatment varies somewhat with the different species, depending upon the amount of material available.

The only attempt at classification is a table in which all insects "without wings" are divided into two groups, those inhabiting the earth and those the water. The "earth" insects are divided into "some with feet" and "some without feet" as earthworms and "mawworms." The "some with feet" include those that "goe with many feet; catterpillers, beetles and such as are called Staphylni," those that "goe with eight feet, scorpions and spiders" and those with six feet, such as "wasps, glow worms, the female Meloe. Also worms in wood, trees, roots, fruits, meats, garments, chambers, humors." The water insects, too, are divided into those "without feet," as the hair-worm and "horsleech," and those "with feet." The latter includes those swimming with six

feet, such as "the Shrimp, the Lake Scorpion, the Notonectus" and those "with many feet" as the "Sea Scolopendra, the many footed Shrimp."

Some of the remedies proposed in Moffett's book seem quite bizarre at this time, as the following quotations show:

Concerning the use of bees in baldness:

Take bees dead in the combs, and when they are through dry make them into powder, as Galen in Euporist. writes, mingle them with honey in which they died, and anoint the parts of the head that are bald and thin haired, and you shall see them grow again.—Page 906.

Propertius is the author of the following distich:

That which forbids the nasty Fly the dish to lick,
Is Peacock's feathers fastened to a stick.
—Page 947.

When cowes or calves are sick, and bellies swell,
They 'ave eat Buprestis keepers known full well.
—Page 1000.

Pliny saith that the Buprestis by way of corrosive doth take away Ringworms in the face. Hippocrates doth much commend them in divers diseases of the womb.—Page 1002.

Faventinus prescribes 21 Chisleps boyled in sowr Oyl, for pains in the ears proceeding from cold; in which he shews that they must be annointed about the ears, and a little must be dropped in.—Page 1049.

If you often apply Oyl or Butter of Hog-lice to a pained head, you shall cure the pain. *Gal. Eupor.* 2.91. Bruised, they cure the Tonsils, and the diseases of the chops, *Dioscor.*—Page 1049.

Concerning cosmetics:

A Maid that cares for her beauty, and would make the circles of her eye-lids black, Emmets eggs bruised with Flies will perform that, and give them their desire.—Page 1080.

For toothache:

Rub a faulty tooth with the Worms in Colewarts, and it will in a few dayes fall forth itself.—Page 1088.

According to Galen:

Worms that breed in hollow and rotten trees heal secret Ulcers and all symptomes of Ulcers, and diseases of the head.—Page 1088.

That trees may not be eaten with worms, plant them in the new of the Moon, and cut them down between the new and old Moon in the conjunction. Also annoint them with Tarre, and often wet them with the lees of Oyl.—Page 1089.

Moffett's magnificent compilation, illustrated by what now would be called wretched woodcuts, was praised by Haller in his notes on Herman Boerhaave's "Methodus Studii Medici." Haller lauded the large amount of information presented about each species and also praised the illustrations. He admitted that Moffett believed too many legendary reports, but placed him above all entomologists before Swammerdam. Hallam did not rate Moffett so highly.

Moffett's other posthumous book, compiled about 1595, was: "Health's Improvement; or Rules comprising and discovering the Nature, Method, and Manner of Preparing all sorts of Food used in this Nation. Written by that ever Famous Thomas Muffett, Doctor of Phisick; corrected and enlarged by Christopher Bennet, Doctor of Physick and Fellow of the Colledg of Physitians of London" (London 1655). According to the account in the "Dictionary of National Biography," on which the present paper is based, his second posthumous book is a loquacious assemblage of rules relating to diet. A second edition was published in 1746. It was Moffett's intention to supplement this by a like book on "drinks."

From all accounts, Moffett had considerable reputation as a physician, chemist and naturalist. Well grounded in the classics, mathematics and medicine, his experience enriched by travel, his association with persons of rank, his knowledge of music, his literary aptitude, as indicated by his books and poem on the silkworm, which Chamberlain said was "no bad piece of poetrie," all

point to high intelligence and culture. Of a religious bias, in the preface of his book on insects, he says, speaking of large animals—"I acknowledge God appears in their magnitude, yet I see more of God in the History of lesser Creatures." With the godless he had little patience, as the following extract, from the preface to the second part of his "Theater of Insects," bears witness:

> Go to therefore bold Atheist, who art ignorant of God and the Divine Perfection; endure, if thou canst, the biting of the Spider Phalangium, or of the Scorpion; abide the pain of the Worm Scolopendra; swallow down the Pine-tree Catterpiller, Contend with Worms, despise with Herod, biting Lice, so much as thou art able, at last thou shalt finde that there is no foot Souldier so mean in this Army, that will not quickly overcome all the forces of thy body and minde, and will make thy foul mouth to confess, by their ministry, that there is a God. Thus then I draw forth my Regiments, so I muster the Souldiers.

Moffett lived at a time when the love of gold and jealousy of Spain were the activating forces behind English navigation; when the control of the seas passed from Spain to England; when Sir Walter Raleigh was making unsuccessful attempts to settle Virginia; when England's colonial expansion started; when the author and publisher of a book that displeased Elizabeth had their right hands cut off with a butcher's knife and mallet in the market place at Westminster; when England was being raised to a first-class power in Europe through Elizabeth and her advisers; when "Gammer gurtons Nedle, a Ryght Pithy, Pleasaunt and merie Comedie" was played in Cambridge; when, according to the "Boke of Nurture, or Schoole of good manners," children were exhorted to say their prayers, brush their clothes, wash their hands, comb their hair, and not to pare their nails at the table, nor pick their teeth with a knife and not to be noisy with their soup or blow upon it; when William Clowes, surgeon, characterized scrofula as a disease known to be cured by the sacred hands of the Queen; when Elizabeth wanted to be considered beautiful and to be loved and when she called the Duke of Alençon her "little frog."

THE PROGRESS OF SCIENCE

EDITED BY DR. EDWIN E. SLOSSON
Director of Science Service

RESEARCHES DESCRIBED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

AMONG reports of general scientific interest presented at the annual meeting of the National Academy of Sciences, held in Washington on April 23 and 24, was a paper by Professor R. W. Wood, of the Johns Hopkins University, describing the work which he and Mr. A. L. Loomis have conducted on sound waves of high frequency. These rays of inaudible sound waves are produced from slices of quartz crystal, driven by oscillating electric currents of frequencies of about 500,000 a second. They travel through any liquid or solid object and heat it as they go, but do not come out into the air. Blood corpuscles in a physiological salt solution are broken down, tingeing the whole body of the fluid a clear red; but if a tiny particle of gelatin—half a per cent. or less—is added, it somehow protects the corpuscles and they are not broken. If a block of artificially frozen ice is subjected to their action, the waves have no apparent effect on it until it is placed under pressure, when it at once breaks into a mass of tiny crystals. But a piece of pond ice, frozen under different conditions, resisted the waves and did not crumble. Finely powdered solids, stirred up in water to make a suspension, are driven together by the waves, until they form a closely packed round mass just under the surface. Things that can not ordinarily be mixed with water, like oil, paraffin and mercury, are forced by the vibrations to become exceedingly fine suspensions or emulsions. A paraffin candle was floated on water and the current turned on. The wax melted from the surface and came down into the liquid in the form of a cloud of microscopic white drops, forming a veritable paraffin milk. In another experiment, a little mercury was poured on the bottom of the beaker full of water. The waves broke it up into drops so small that they could just be seen with the highest power of the microscope, scattered evenly through the water in a dense cloud. This mercury-water emulsion was as black as ink.

THE studies of Dr. F. E. Wright, of the Geophysical Laboratory of the Carnegie Institution of Washington, which he described at the meeting of the academy, indicate that the surface of the moon consists of such rock as pumice and granite, with no basalt. And as basalt is almost invariably associated with volcanic activity as far as we know, this is rather a jolt to the theory that the moon was once the scene of vast volcanic activity, producing the craters that are such a familiar feature of its surface. The light reflected from the moon is partly polarized, and by determining the degree of polarization it is possible to learn something of the nature of the reflecting surface. At different phases of the moon, the light is reflected to the earth at different angles, and by comparing with it the polarization of light reflected from earthly rock surfaces, Dr. Wright has found that rocks containing large amounts of silica, such as pumice, granite, quartzporphyry, as well as sulphur and powders of transparent substances, polarize light reflected from their surfaces much in the same way as the moon does. But basalt, a rock due

DR. THOMAS HUNT MORGAN

PROFESSOR OF EXPERIMENTAL ZOOLOGY IN COLUMBIA UNIVERSITY, WHO HAS BEEN ELECTED PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES TO SUCCEED PROFESSOR A. A. MICHELSON.

to volcanic causes, affects the light quite differently. At best, however, the amount of polarized light reflected from the moon is very slight, and at new moon and full moon is practically absent.

WHAT seems to be a solution of the problem of how the heat and light radiated from the sun vary was announced by Dr. C. G. Abbot, acting secretary of the Smithsonian Institution. While it has been known for nearly a century that the sun undergoes an eleven-year cycle during which sun spots wax and wane, and that the intensity of the radiation follows somewhat in step, the correspondence is not close enough to permit advance predictions of what the radiation will be. Dr. Abbot took values for the intensity of solar radiation found by the Smithsonian's Astrophysical Observatory for a period of 77 months, ending October, 1926. These were analyzed by Dr. Dayton C. Miller, of the Case School of Applied Science, in an ingenious machine of his invention, known as the harmonic analyzing machine. The results show that there is a marked period of about 25 2/3 months, and two others less strongly marked of 15 2/5 months and of 11 months. The combination of these periods produces a very complicated variation, which has hitherto been supposed to be without any regularity whatever. As the sun affects terrestrial conditions, such as long range radio reception, and as it has already been found that the world's rainfall average undergoes a variation of 15 2/5 months, corresponding with the one Dr. Abbot has found in solar radiation, he is hopeful that prediction of the intensity of solar radiation, and the effects attendant on it, may soon be possible.

THE loss in weight that we all undergo every day, mostly water given off through the skin and lungs, has been the object of research by Dr. Francis G. Benedict and Cornelia Gollay Benedict, of the Carnegie Institution of Washington. Two sensitive balances were used in the work. Both were strong enough to sustain the weight of a man, but sensitive enough to register small changes in weight. One of the balances would indicate a change of one third of an ounce, and was so constructed that the volunteer for the experiment could sleep all night on its platform. The other was a hundred times as sensitive, but could be occupied for only an hour or so at a stretch. The total moisture losses of this class from a woman of average weight were found to average about 30 grams, or one ounce, per hour; for a man the figure was about a third higher. An auxiliary device permitted the separate measurement of losses from the lungs and skin, and while these varied among individuals and from time to time in the same individual, they averaged 50 per cent. from each source of water loss. Other ingenious mechanisms measured the carbon dioxid given off, the percentage of water in the outgoing breath and also its temperature.

USING an electrical heat-measuring device so incredibly delicate that it is sensitive to two trillionths of an ampere of current and will measure temperature changes of as little as one ten-millionth of a degree Centigrade, Dr. A. V. Hill, of the University of London, has measured the temperature changes in nerve fibers during their activity. In describing his experiments before the academy, he stated that his object had been to learn more about the nature of nervous action. Older theories have held that nervous impulses were not like other physiological processes, but were physical waves like light or radio waves. These ideas were based on the absence of any detectible heat given off by

BENEDICT DE SPINOZA

THE GREAT DUTCH PHILOSOPHER, THE TWO HUNDRED AND FIFTIETH ANNIVERSARY OF WHOSE DEATH IS THIS YEAR BEING WIDELY COMMEMORATED.

nerves as a result of stimulation. But with the extremely sensitive instrument devised by Dr. Hill it is possible to measure the almost vanishingly minute temperature rise that occurs in a single nerve fiber when it is caused to react. The moment of activity of a nerve is followed by a prolonged period of recovery, during which nine times the initial amount of heat is given off.

CHEMICAL methods to arouse seed potatoes and other plant cuttings from their lethargy and start them into growth weeks before the usual time were described by Dr. Frank E. Denny, of the Boyce Thompson Institute, Yonkers, N. Y. Potato tubers when freshly harvested are dormant, and will not sprout if planted at once under growing conditions, the rest period lasting from 1 to 4 months in different varieties of potatoes. This period of inactivity may be shortened by treating the tubers with various chemicals. The gain in time of sprouting is about 2 to 6 weeks, depending on the variety of potato and the stage of dormancy at the time the treatment is applied. Twigs of apple, grape, lilac, also have this dormant period in autumn, and the buds of these species can be forced into early growth by treatment with certain of these chemicals, the gain in time of budding or blooming ranging from 1 to 9 weeks. The chemicals used by Dr. Denny include thiocyanates, thiourea and ethylene chlorhydrin.

BORING for live steam as men bore for oil, with the possibilities of running engines and turning dynamos without the burning of fuel, was described by Dr. Arthur L. Day, of the Carnegie Institution of Washington. The steam wells are in Sonoma County, Calif., where operations have been going on for some time to exploit a field of hot springs and steam vents similar to those of Yellowstone National Park but on a smaller scale. So far five borings have been sunk. They reach depths of from 300 to 600 feet, yielding a total of nearly 5,000 horsepower of live steam. The temperatures at the bottoms of the wells vary from 160 to 185 degrees, and the pressures attain a maximum of 276 pounds per square inch. Besides steam, various gases come out of the wells, making up less than two per cent. by volume of the product. Similar wells have been operated on a large scale for several years in Italy. Concerning these, Dr. Day remarked, "Compared with the development of natural steam in Tuscany, where more than 30,000 H.P. is now commercially developed, the conditions in California appear to be somewhat more favorable from the point of view of the uncondensable gases carried and their corrosive effect upon metals. The total power available is probably smaller. The oldest of the California wells has now been flowing intermittently for five years with undiminished pressure."

"SEA-LEVEL," the standard to which land heights are referred, is not such a definite thing, Professor Douglas Johnson, of Columbia University, told members of the academy. Local configurations of the shore line may have a great effect, and as extreme examples of the effect he cited the case of the Bay of Fundy, which is wide at the mouth, but gets narrow towards the head, so that the high tide in the bay is much higher than in the open sea. On the other hand, a broad bay, connected to the sea by a narrow inlet, may never have a tide as high as in the ocean outside because the water can not pour in through the inlet fast enough to fill up the bay before the tide outside begins to fall again. These are extreme cases, but that much less clearly marked irregularities of the coast may produce considerable effect

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has been shown by studies around the city of New York. In some places the crest of high tide was found to be nearly two feet higher than others. On this account any local changes in the shoreline may affect the mean sea-level, and so produce an apparent settling or rising of the coast line.

THE fossil-bearing rocks of the Grand Canyon, which have recently aroused much interest because of the discovery in them of footprints of long-extinct animals, are now yielding remains of the leaves and stems of plants among which these animals roamed and fed many millions of years ago. At the meeting of the academy Dr. David White, of the U. S. Geological Survey, told of his examination and identification of many specimens from this region. The plants that grew on the ancient floodplain of red sand through which the great gash of the Grand Canyon has since been cut were very little like the ones that grow in the forests of to-day. Their nearest relatives still living are the ferns and the tropical cycads and similar plants. The plant remains were all preserved by being deposited at the bottoms of streams or ponds, but there is evidence that these bodies of water were not permanent, but appeared during rainy seasons and dried up when the rains ceased.

THE CHILDHOOD OF GREAT MEN

From Punch

BENJAMIN FRANKLIN, AT THE AGE OF FIVE, HAS AN IDEA THAT LIGHTNING MIGHT BE BETTER CONDUCTED.

LITTLE CHARLES DARWIN BEGINS TO CONSIDER.

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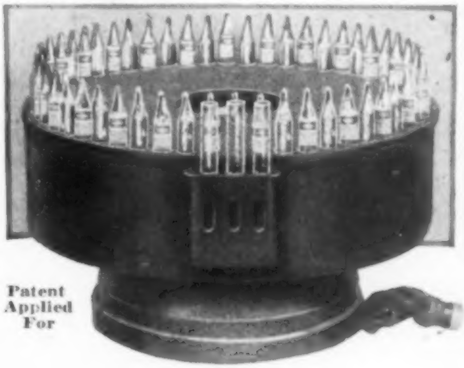

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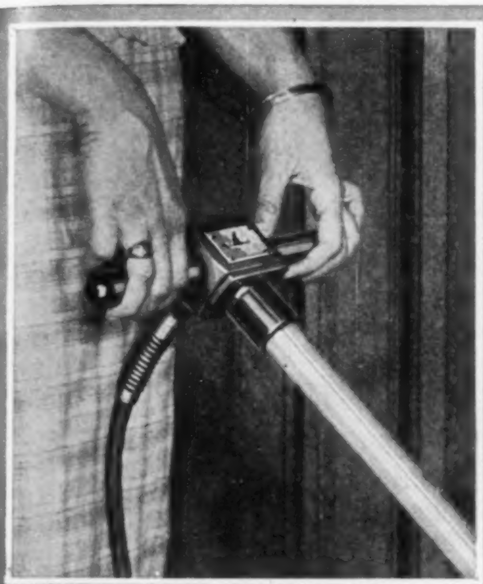

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